

AD-A261 192



2

CEL-TR-92-10

ARMOR-HARDENED P-19  
CRASH/FIRE/RESCUE  
(CFR) VEHICLE  
PERFORMANCE TEST,  
PHASE I'

L. G. HORNER

OAK RIDGE NATIONAL LAB  
OAK RIDGE, TN

APRIL 1992

FINAL REPORT

JUNE 1989 - SEPTEMBER 1990

APPROVED FOR PUBLIC  
RELEASE: DISTRIBUTION  
UNLIMITED

DTIC  
ELECTE  
FEB 25 1993  
S B D

93-03955



ENGINEERING RESEARCH DIVISION  
Air Force Civil Engineering Support Agency  
Civil Engineering Laboratory  
Tyndall Air Force Base, Florida 32403



98 2 24 075

NOTICE

PLEASE DO NOT REQUEST COPIES OF THIS REPORT FROM  
HQ AFESC/RD (ENGINEERING AND SERVICES LABORATORY).  
ADDITIONAL COPIES MAY BE PURCHASED FROM:

NATIONAL TECHNICAL INFORMATION SERVICE  
5285 PORT ROYAL ROAD  
SPRINGFIELD, VIRGINIA 22161

FEDERAL GOVERNMENT AGENCIES AND THEIR CONTRACTORS  
REGISTERED WITH DEFENSE TECHNICAL INFORMATION CENTER  
SHOULD DIRECT REQUESTS FOR COPIES OF THIS REPORT TO:

DEFENSE TECHNICAL INFORMATION CENTER  
CAMERON STATION  
ALEXANDRIA, VIRGINIA 22314

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE April 1992		3. REPORT TYPE AND DATES COVERED Final Report
4. TITLE AND SUBTITLE Armor-Hardened P-19 Crash/Fire/Rescue (CFR) Vehicle Performance Test, Phase II			5. FUNDING NUMBERS	
6. AUTHOR(S) L. G. Horner				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Oak Ridge National Laboratories Oak Ridge, Tennessee			8. PERFORMING ORGANIZATION REPORT NUMBER None	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) HQ AFCEA/RACF (LAB) Tyndall AFB, Florida 32403-6001			10. SPONSORING/MONITORING AGENCY REPORT NUMBER CEL-TR-92-10	
11. SUPPLEMENTARY NOTES None				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  An effective hardening kit has been designed for the P-19 Firefighting and Crash Rescue vehicle which will protect the vehicle and operators from injury from submunition fragments in a postattack environment. The kit is designed to provide the vehicle and its occupants a 95 percent probability of surviving 100 random events, using the NATO Standard Fragment Threat Criteria. It consists of 36 mild steel panels, 7 Lexan <sup>™</sup> transparent panels, 8 flexible Kevlar <sup>™</sup> 49 panels, the appropriate fasteners for attaching the panels, and a set of spare wheels with tires filled with ARNCO Superflex, water-based polyurethane foam. The use of the hardening kit greatly enhances the safety of the firefighters and better enables them to perform effectively in a postattack environment.  Complete drawings are available in hard copy and as Autocad drawings on computer disk through AFCEA/DF.				
14. SUBJECT TERMS			15. NUMBER OF PAGES 53	
			16. PRICE CODE --	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

## EXECUTIVE SUMMARY

### A. OBJECTIVE

The objective of this effort was to develop the methodology and design for a generic wartime hardening system for use of firefighting crash rescue vehicles. Specifically, a hardening kit was designed, constructed, installed, and tested on a P-19 fire fighting vehicle.

### B. BACKGROUND

After attack, wartime firefighters must perform their mission in a harsh environment. Debris, unexploded bombs, and munitions pose life-threatening hazards. Without modification to the firefighting vehicles, there is little assurance that the firefighter would even be able to reach the fire incident locations. Adding armor to the vehicle to protect both the operator and the vehicle from the hazards is the proposed solution.

### C. SCOPE

An effective hardening kit has been designed for the P-19 Firefighting and Crash Rescue vehicle which will protect the vehicle and operators from injury from submunition fragments in a postattack environment. The kit is designed to provide the vehicle and its occupants a 95 percent probability of surviving 100 random events, using the NATO Standard Fragment Threat Criteria. It consists of 36 mild steel panels, 7 Lexan™ transparent panels, 8 flexible Kevlar™ 49 panels, the appropriate fasteners for attaching the panels, and a set of spare wheels with tires filled with ARNCO Superflex™, water-based polyurethane foam. The use of the hardening kit greatly enhances the safety of the fire fighter, enabling him to perform more effectively in a postattack environment.

### D. CONCLUSION

The results of this project indicate that it is feasible to armor a P-19 crash-rescue vehicle to provide protection to the vehicle and its occupants from postattack hazards. The proposed method for accomplishing this is to have a hardening kit available for each vehicle which is at risk. The total armor kit weight is approximately 5,900 pounds. This additional weight will have a minimal effect upon the vehicle.

In summary, it is believed that the use of the hardening kit will greatly enhance the safety of the firefighter and better enable him to perform his/her mission in a postattack environment. P-19 firefighting vehicles should be modified with the armor attachment points. Armor kits should be procured and located with WRM stocks, ready for wartime use. When the threat level reaches a predetermined point, the armor kit would be installed, per the installation procedure provided in Appendix A, and left on the vehicle until the danger of debris, unexploded bombs, and munitions is past.

Complete drawings are available in hard copy and as Autocad drawings on computer disk through AFCESA/DF.

## PREFACE

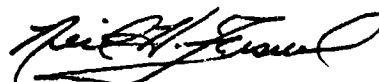
This report was prepared by the Civil Engineering Laboratory, Air Force Civil Engineering Support Agency, Tyndall Air Force Base, Florida 32403.

Mr. Hugh A. Pike, AFCESA/DF (formally of AFCESA/RACF), was the Project Officer. This report presents the results of the Armor-Hardened P-19 Crash/Fire/Rescue (CFR) Vehicle Performance Test, Phase II, conducted between June 1989 and September 1990 at Oak Ridge National Laboratories, Oak Ridge, Tennessee.

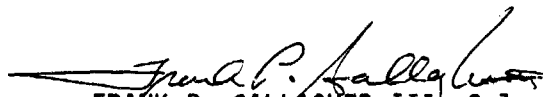
This test report has been reviewed and is approved.



RICHARD N. VICKERS  
Chief, Airbase Fire Protection  
and Crash Rescue Systems Branch



NEIL H. FRAVEL, Lt Col, USAF  
Chief, Engineering Research Division



FRANK P. GALLAGHER III, Colonel USAF  
Director, Civil Engineering Laboratory

DTIC QUALITY INSPECTED 3

Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

## TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION.....	1
	A. TEST OBJECTIVES.....	1
	B. BACKGROUND.....	1
	C. MEASURES OF MERIT.....	2
	D. SCOPE/APPROACH.....	2
II	METHOD OF TEST AND TEST RESULTS.....	8
	A. INTRODUCTION.....	8
	B. APPROACH.....	8
	C. METHOD OF TEST.....	8
	D. SPECIFIC TESTS AND TEST RESULTS.....	10
III	CONCLUSIONS AND RECOMMENDATIONS.....	28
	A. CONCLUSIONS.....	28
	B. RECOMMENDATIONS.....	28
APPENDIX		
A	P-19 FIRE VEHICLE HARDENING KIT INSTALLATION PROCEDURE..	29

## LIST OF FIGURES

Figure	Title	Page
1	Unhardened P-19 Firefighting Vehicle.....	2
2	P-19 Firefighting Vehicle with Hardening Kit Installed..	4
3	P-19 Armor Kit Installation.....	6
4	P-19 Prototype Armor Kit Installed.....	6
A-1	Target Panels, Front.....	43
A-2	Target Panels, Rear.....	43
A-3	Target Panels, Bottom.....	44
A-4	Target Panels, Side.....	44
A-5	P-19 Ready for Hardening Kit Installation.....	45
A-6	P-19 with Hardening Kit Installed, Front-Left View.....	46
A-7	P-19 with Hardening Kit Installed, Left-Rear View.....	47
A-8	P-19 with Hardening Kit Installed, Bottom Rear View.....	48

## SECTION I

### INTRODUCTION

#### A. TEST OBJECTIVES

The following are the overall objectives of this test series.

1. Determine the effects of the prototype armor-hardening kit upon the performance and functional operation of a P-19 CFR vehicle.
2. Determine the ease or difficulty and the time required to install the hardening kit.
3. Assure that the correct parts, tools, and instruction manual are provided so that Air Force personnel can install the kit without special training.
4. Inspect for adequacy of the kit's design, fit, and armor coverage.
5. Assure accessibility to functional portions of the vehicle with the kit installed.

#### B. BACKGROUND

The Fire Technology Branch of the Air Force Engineering and Services Center at Tyndall Air Force Base in Florida realized that a critical need existed for protecting firefighters and their equipment in a wartime environment. They proposed that engineering studies be conducted to determine the requirements and methods for "hardening" a P-19 crash/fire/rescue (CFR) vehicle. This task was assigned to Martin Marietta Energy Systems, Inc., through an interagency agreement between Tyndall Air Force Base and the Department of Energy (DOE).

Studies were conducted to determine the characteristics of the vehicle, especially as affected by additional weight, and the vulnerable areas of the vehicle. Types, thicknesses, and locations of armor material were determined, and a preliminary design for a hardening kit was produced. After completion of the preliminary design, a P-19 was made available for modification. This vehicle had armor attachment points installed and a wooden mock-up kit installed to aid in the design refinement. This vehicle was returned to the Air Force and another P-19 was made available. The second P-19 was modified using the existing drawings in order to verify the suitability of the drawings for different P-19 vehicles and to make any refinements necessary. A prototype armor kit was fabricated using the specified armor materials. The drawings were modified to reflect any changes necessitated by changing from the wooden mock-up to the metal, Kevlar<sup>™</sup>, and Lexan<sup>™</sup> materials.

After armor kit fabrication, Air Force personnel were provided a set of written instructions describing the kit installation. Using these instructions, the kit was installed, and the instructions were modified to reflect problems noted during the practice installation.



Testing of the unarmored P-19 was conducted to determine baseline operating characteristics. These same tests were repeated with the complete armor kit installed in order to determine the effects of the kit on vehicle mission performance.

#### C. MEASURES OF MERIT

The overall measures of merit for the program were that the armored-hardened P-19 firefighting vehicle should be not have its operational capability reduced by the installation of the hardening kit. Specific criteria for the individual test are listed with the test results in Section III of this report.

#### D. SCOPE/APPROACH

##### 1. Vehicle Characteristics

A decision was made to concentrate the initial efforts of this program on the P-19 crash-rescue vehicle that is shown without armor in Figure 1. The techniques and lessons learned from hardening a P-19 were believed to be easily applied to other vehicles in an efficient manner.



Figure 1. Unhardened P-19 Firefighting Vehicle

The first step in the procedure was to analytically predict the characteristics of the P-19 vehicle as it would be affected by additional weight and the effect of rigid tires on the suspension, component design life, and operational requirements. This task was subcontracted to the BDM Corporation because of their previous experience with hardening construction vehicles for the Rapid Runway Repair Program. The results of BDM's investigation indicated that up to 4,000 pounds of armor may be added to the P-19 without incurring a significant performance penalty. The actual effects of the additional weight of the kit and of the rigid tires were determined by testing of a vehicle, first without armor, then with armor installed.

## 2. P-19 Vulnerability

BDM determined that the key vulnerable areas of the P-19 were the cab enclosure, drive train, undercarriage, agent proportioning, fuel, electrical lines, and dispensing system. Next, the vulnerability of each critical component to the NATO Standard Fragment Threat Criteria was determined and the amount and type of hardening necessary was estimated.

## 3. Materials

The BDM Corporation was also utilized to perform a survey of materials suitable for armoring a P-19 vehicle. Mild steel was selected as the primary hardening material with Lexan<sup>™</sup> to be used for the transparent material and Kevlar 49<sup>™</sup> to be used to protect certain lines and areas requiring flexibility. During fabrication of the prototype armor kit, it was decided to use Kevlar 29<sup>™</sup> rather than Kevlar 49<sup>™</sup> due to better availability, lower cost, and equivalent protection afforded by the Kevlar 29<sup>™</sup>. ARNCO Superflex<sup>™</sup> water-based polyurethane foam was selected as the fill material for the tires. During fabrication of the prototype kit, a better definition of the desired mission of the P-19 was determined, and a decision was made to use ARNCO RePneu<sup>™</sup>.

## 4. Parametric Studies

To conclude their studies, BDM performed a parametric study to determine the minimum weight and cost option to harden the P-19 based on ease of fabrication, ease of installation, and on durability. The results of this study produced the information necessary to make recommendations for designing the hardening kit.

## 5. Hardening Kit Design

Based on the BDM recommendations, a detailed preliminary design for the hardening kit was initiated. Because of the unavailability of P-19 engineering drawings, actual measurements were made of the vehicle. From this information, initial panel drawings were completed, but the attachment devices and locations were omitted. This initial design consisted of (1) 36 mild steel panels varying in thickness from 0.125 inch to 0.375 inch, (2) 7 1.5-inch-thick Lexan<sup>™</sup> panels, and (3) 8 Kevlar<sup>™</sup> panels.

To finalize the design, it was necessary to have Maintenance personnel work with an actual vehicle to determine how and where appropriate attachment points could be located. Once this was determined, mock-up armor was fabricated from 1/8-inch aluminum plate and fitted to the vehicle. Thin Plexi-

glas<sup>™</sup> panels were used to simulate the thicker and heavier Lexan<sup>™</sup> panels that would be used in the actual hardening kit, and canvas was used to simulate the Kevlar 29<sup>™</sup> which is required in the actual kit. A photograph of the vehicle with the mock-up armor installed is shown in Figure 2.

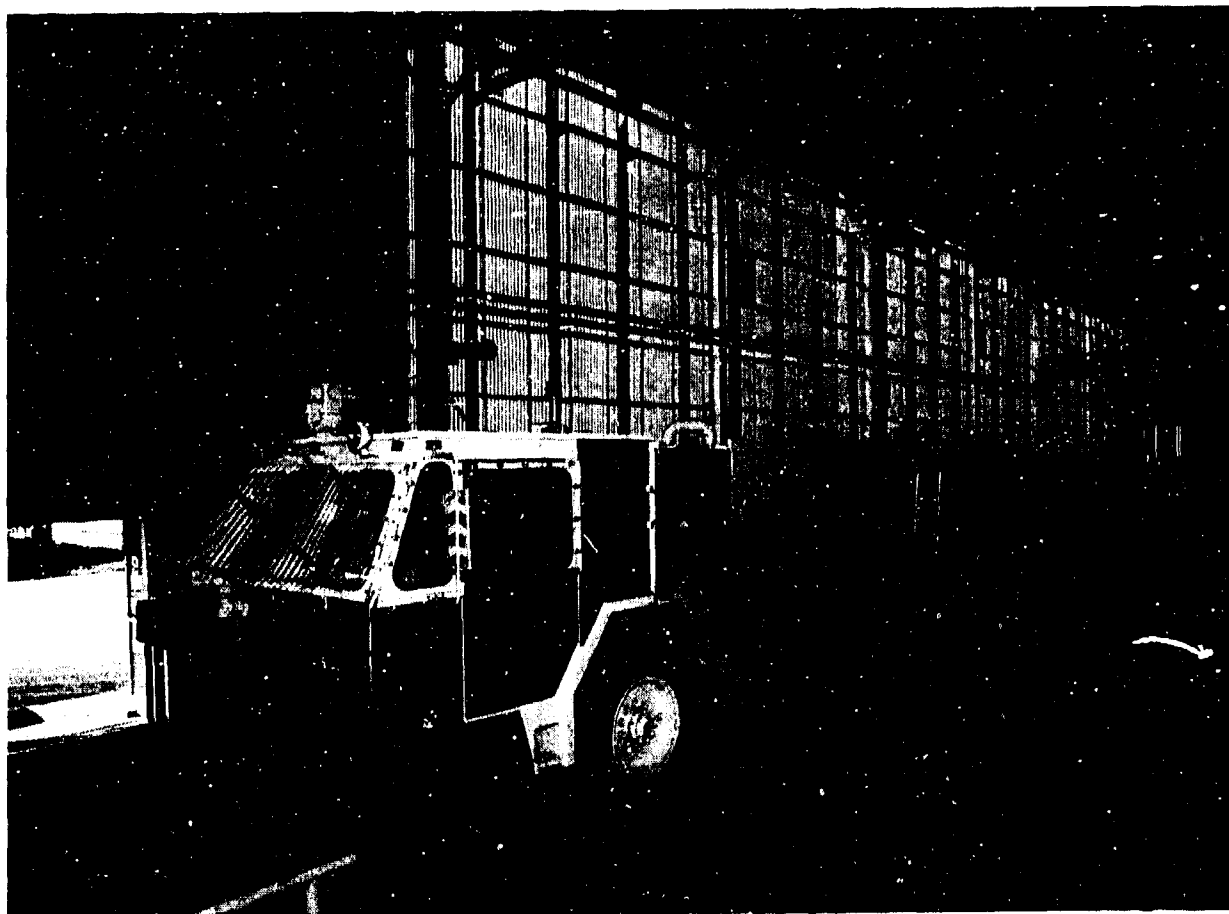


Figure 2. P-19 Fire Fighting Vehicle with Hardening Kit Installed

After completion of the installation of the mock-up armor on the P-19, the vehicle was inspected by Air Force personnel. Several changes and additions were suggested for incorporation in the design. The suggested changes and additions are as follows.

- a. Add a panel or protection to the cab step area.
- b. Add panels to the front wheel wells to protect the cab.
- c. Add panels to the rear upper tank area (same height as side panels).
- d. Add panels to the upper front of the rear wheel wells.

- e. Wrap brake lines with Kevlar<sup>™</sup>.
- f. Remove all handles from the truck to eliminate having to make cutouts in the armor panels.
- g. Secure side panels at the bottom
- h. Use large rings on the fastening pins.
- i. Close up lower rear gaps in Kevlar<sup>™</sup> blankets.
- j. Increase clearance on the panel behind the cab to compensate for vehicle twist.
- k. Increase the size of the Kevlar<sup>™</sup> blanket between the cab and halon tank door.
- l. Install handles on all panels weighing over 50 pounds that have no hinges or natural handles.
- m. Extend windshield wiper attachments rather than make windshield cutouts.
- n. Keep the number of attachment bolts to a minimum.

When the second P-19 vehicle was received and final design of the armor kit was initiated, the above items were incorporated into the design. Many unanticipated changes were also necessary. Quite a few of these changes were due to the difficulties encountered in forming the steel armor material compared to the fabrication of the easily worked aluminum. Other changes resulted from dimensional differences between the two P-19s. Changes, such as slotting many of the round holes, in an effort to accommodate as many of the vehicle inconsistencies as possible, were made in the kit components. Modifications were made to the vehicle internal air supply system in order to utilize the system for powering air-operated tools for kit installation in the field. The quick disconnect fitting is installed in the lower center compartment on the right side of the vehicle. An access panel was designed and installed on top of the engine compartment so that the engine can be serviced with the armor installed. The type of Kevlar<sup>™</sup> was changed from 49 to 29 due to a suggestion made by the manufacturer of Kevlar<sup>™</sup>. This was done due to the better availability of Kevlar 2<sup>™</sup>, its lower cost, and its ability to give the same performance. A change was also made to waterproof the Kevlar<sup>™</sup> at the supplier by having it treated with either Zepel<sup>™</sup> or Scotchguard<sup>™</sup> and to have the Kevlar<sup>™</sup> panels encased in waterproof/light-tight bags. These changes were necessary due to the characteristics of Kevlar<sup>™</sup> to deteriorate when exposed to direct sunlight and due to its losing as much as 50 percent of its fragment stopping power when wet. This stopping power is restored when the Kevlar<sup>™</sup> has dried. Another change was made in the thickness of the Lexan<sup>™</sup> window panels. The required thickness of the panels was reduced from 1.5 inch to 1.25 inch due to the difficulty of procuring the 1.5-inch material. The fragment-stopping power of the 1.25-inch material will still meet the requirements.

The armor kit being installed is shown in Figure 3 with the P-19 with the complete prototype armor kit installed shown in Figure 4.



Figure 3. P-19 Armor Kit Installation

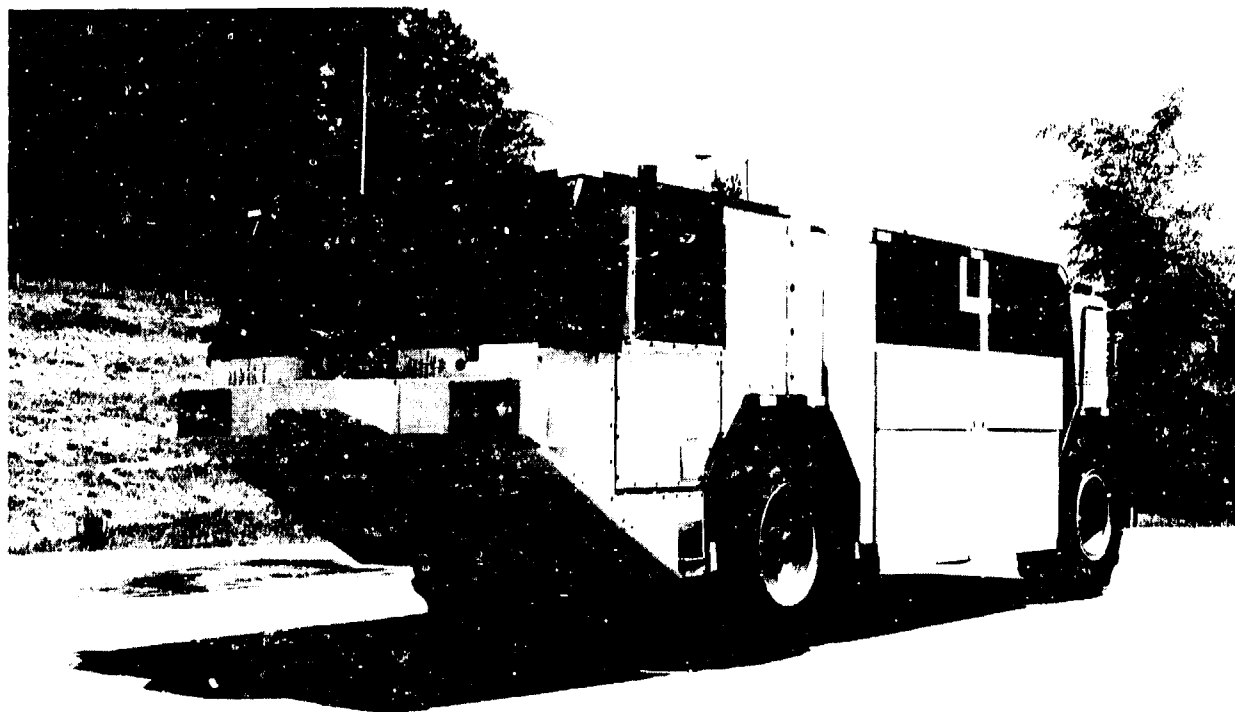


Figure 4. P-19 Prototype Armor Kit Installed

## 6. Testing

In order to evaluate the effects of adding armor to a P-19 vehicle, it was necessary to conduct a series of tests. The tests were first conducted on an unarmored P-19 to obtain baseline data, then on a fully armored P-19 to determine the differences caused by the armor kit.

Testing consisted of determining vehicle/armor interference points; evaluating armor installation methods; weighing the vehicle to determine overall weight and weight distribution; obtaining acceleration, braking, and handling characteristics; and evaluating the effects of the foam-filled tires.

## SECTION II

### METHOD OF TEST AND TEST RESULTS

#### A. INTRODUCTION

This section describes a series of tests completed on an Air Force prototype armor-hardened P-19 fire truck. The P-19 fire truck was fitted with a newly designed armor-hardening kit. The armor-hardening kit consists of approximately 50 steel armor panels, 7 Lexan™ transparent panels, a number of flexible Kevlar™ panels, and a set of four spare wheels filled with polyurethane foam. The armor will add approximately 3,500 pounds to the sprung weight of the vehicle and approximately 850 pounds of unsprung weight to each of four wheels. The fully loaded, unmanned vehicle weight will increase from approximately 33,000 pounds to approximately 40,000 pounds by installing the armor kit. These tests addressed the impact of the additional weight on the vehicle's ability to accomplish its mission. In the operational environment, the kit will be installed on the trucks only under specified alert conditions.

#### B. APPROACH

Limited performance comparison tests were conducted on a fully loaded P-19 fire truck with and without the hardening kit installed. Comparison of the test results permitted a quantified measure of effect that the armor kit had on the performance and function of the hardened P-19 truck. First, the standard truck was tested for baseline unarmored vehicle performance parameters. Next, the hardening kit was installed onto the P-19 truck by Air Force personnel using standard kit parts, tools, and installation manual. Inspections were performed for ease and time of installation, fit, design, armor coverage, and access to functional portions of the vehicle. The armor-hardened truck was then tested to evaluate its performance. The performance of the vehicle in unarmored and armored configurations were compared. The results were used to evaluate the practicality of the hardening concept for the P-19 CFR vehicle.

#### C. METHOD OF TEST

Selected items were evaluated to provide a preliminary quantitative measure of the P-19 vehicle performance degradation due to the additional sprung and unsprung weight resulting from installing the hardening kit. These items are as follows:

1. Vehicle Weight (empty and fully loaded)
  - a. Tires
    - Wheel weight
    - Footprint area
    - Tire temperature build-up
  - b. Suspension
    - Spring deflection

- Adequate clearance for suspension, chassis, tire, and tire well under static deflected conditions - hole, bump, hard left, hard right, and combinations.
  - Potential points of contact or damage for suspension, chassis, tire, and tire well under dynamic conditions over a designated obstacle.
- c. Vehicle braking
  - d. Vehicle acceleration on smooth level pavement
  - e. Vehicle handling
    - Turning radius, slow
    - Cornering, a timed obstacle course on smooth, level surface.
  - f. Armor-hardening kit installation
  - g. Equipment access and operability

## 2. Vehicle Test Weight

a. For purposes of these tests, the fully loaded vehicle weight included a Three-fourths-full fuel tank, the normal 1,000 gallons of water in the water tank, and 130 gallons of aqueous film-forming foam (AFFF) (or equivalent weight of water) in the AFFF tank. The 500 pounds of Halon 1211 normally carried on board the vehicle was omitted for convenience of these tests. An equivalent 500 pounds of ballast was added to the vehicle to compensate for the omitted Halon 1211. Portable firefighting equipment was not included in the truck weight.

b. A driver and one passenger were on board for most performance tests. Vehicle weight and weight distribution were taken with only the driver in the truck.

c. For reference, the standard and hardened P-19 vehicle total empty weight were measured. The empty vehicle includes 3/4-full fuel tanks, a driver, but no firefighting water, AFFF, or Halon 1211.

## 3. Limited Vehicle Brake Tests

Braking tests consisted of five successive stops from 20 mph for the standard and armored truck configurations. These brake data were for simple comparison only. The more extensive SAE-J880 brake system grading tests are not planned as part of these comparison tests because Warner Robins Logistics Center has an extensive P-19 vehicle brake test series and a study under way with Southwest Research Institute (SRI) in San Antonio, Texas. It is recommended that an armored P-19 vehicle be added to the vehicle brake tests at SRI.



## D. SPECIFIC TESTS AND TEST RESULTS

### 1. Vehicle Weight

#### a. Objective

The objective of this test was to determine the total weight (empty and fully loaded) and weight distribution for the standard and hardened P-19 in the loaded condition.

#### b. Criteria

The weight distribution requirements for a fully loaded, un-manned vehicle was that the weight difference between wheels on the same axle shall be no more than 5 percent of the average weight of the wheels on the axle. The difference in load between axles shall be no more than 10 percent of the average axle load. These weight distributions shall be taken for the fully loaded standard and hardened P-19 vehicle.

#### c. Data Acquisition Procedure

The standard and hardened vehicles shall be weighed at each wheel, each axle, and the entire vehicle using a standard truck platform scale. Wheel, axle, and vehicle weights were checked for consistency. Weight distribution was determined by calculation.

#### d. Results

#### WEIGHT FOR THE EMPTY TRUCK

Wheel Location	P-19 Weight, pounds	Hardened P-19 Weight, pounds
Left Front	5,680	7,330
Right Front	4,920	7,360
Left Rear	5,700	7,370
Right Rear	5,770	7,290
Total Vehicle	22,070	29,350

## WEIGHT FOR THE FULLY LOADED TRUCK

Wheel Location	P-19 Weight, pounds	Hardened P-19 Weight, pounds
Left Front	8,070	9,340
Right Front	7,110	9,410
Left Rear	8,090	9,340
Right Rear	8,050	9,130
Front Axle	15,180	18,750
Rear Axle	16,140	18,470
Avg. Front Wheel	7,590	9,375
Avg. Rear Wheel	8,070	9,235
Avg. Axle	15,660	18,610
Total Vehicle	31,320	37,220

### e. Analysis

#### PERCENT DIFFERENCE IN WEIGHT DISTRIBUTION

Between wheels on the same axle			
	Standard P-19 percent	Hardened P-19 percent	Required percent
Front	6.3	0.4	≤5
Rear	0.2	1.1	≤5
Between Axles			
	3.1	0.8	≤10

Extra weight of the armor plus hardened tires was 5,900 pounds (37,200-31,320). Polyurethane fill in the four tires was approximately 2,973 pounds (5,260-2,287) or 743 pounds per tire. The total loaded hardened vehicle weight was approximately 19 percent higher than the standard loaded P-19 vehicle.

## 2. Tires and Wheel Weight

### a. Objective

The objective of this test was to determine the average unsprung weight added to the P-19 vehicle by the introduction of polyurethane foam to the hardened tires.

### b. Criteria

There were no specific tire weight criteria or requirement. The wheel weight data were recorded to aid in evaluating any effects the increased unsprung weight might have on vehicle handling, braking, or operation over obstacles and rough terrain. Four new air-filled tires mounted on

rims inflated to 60 psig and four new polyurethane foam-filled tires mounted on spare rims were used for these tests.

c. Data Acquisition Procedure

Weigh each of four air-filled wheels.

Weigh each of four foam-filled wheels.

A platform scale was used to weigh the wheels.

d. Results

WHEEL WEIGHTS		
Wheel Location	Air-Filled Wheel pounds	Foam-Filled (hardened) Wheel (pounds)
LF	568	1,315
RF	572	---
LR	573	---
RR	574	---
Total	2,287	5,260 (EST)

e. Analysis

	Air-Filled Wheel (pounds)	Foam-Filled (hardened) Wheel (pounds)
Average Wheel Weight	572	1,315

3. Tire Footprint Area

a. Objective

The tire footprint area and load per unit area of the armor-hardened and standard P-19 fire truck were measured and compared.

b. Criteria

There were no specific tire footprint or contact pressure criteria or requirement. The footprint area along with tire loads provided an estimate of tire contact pressure which was used to provide an early comparison of tractability of the hardened and standard P-19 vehicles in rough and soft soil. Two contact areas were evaluated; the area of the treads only and the contact patch area of both treads and grooves enveloped by the outer treads.

#### c. Data Acquisition Procedure

All tests were completed with new tires, both air-filled and foam-filled. Footprint area of the fully loaded, standard, and hardened truck were made of the left front wheel. The left front wheel was jacked up, a clean piece of paper was placed under the wheel, and the truck was lowered onto the paper. The front wheel was steered slightly left and right to assure the paper was marked. The tire was jacked up, the paper was removed, and the contact area on the paper was measured and reported.

#### d. Results

	<u>Standard</u>	<u>Hardened</u>
Tire, left front LF tire load*	8070	9340
LF tire contact area		
Treads only (in <sup>2</sup> )	79.4	54.3
Enveloped treads and (in <sup>2</sup> ) grooves	156.4	102.1

\* From vehicle weight distribution data.

#### e. Analysis

Contact pressure		
Treads only, load/area, lb/in <sup>2</sup>	101.6	172.0
Envelope of treads and grooves load/area, lb/in <sup>2</sup>	51.6	91.5

The tire footprint area of the hardened P-19 vehicle was approximately 32 percent to 35 percent less than the standard vehicle. The tire contact pressure of the hardened vehicle is 69 percent to 77 percent greater than the standard vehicle. The hardened P-19 vehicle is expected to not maneuver as well in soft terrain as does the standard P-19.

#### 4. Tire Temperature Build-up

##### a. Objective

The objective of this test was to measure the difference in tire temperature build-up between air-filled and foam-filled tires when the vehicle was driven under an arbitrarily selected postulated temperature increase operating condition.

##### b. Criteria

There were no known specific P-19 tire temperature criteria or requirements. When operated continuously at high speeds, polyurethane foam-filled tires tend to generate more heat than pneumatic tires. It was desir-

able to determine if there was a significant difference in tire temperature build-up. The data from this test may be helpful in predicting if any measured temperature build-up would be detrimental to the foam-filled tires.

The selected polyurethane fill for the 17.5 R25 radial-ply tubeless tire, with standard P-19 operating air pressure of 60 psi, was RePneu<sup>™</sup> manufactured by the ARNCO Company. For the heavier armored P-19, the ARNCO RePneu<sup>™</sup> fill was placed in Michelin tires to a pressure equivalent of 70 psi air pressure. This results in a rated capacity of 10,000 pounds per tire for 35 mph continuous operation. ARNCO recommends RePneu<sup>™</sup> for tires with pressure ratings between 50 psi and 125 psi and high-speed applications between 35 and 55 mph. Although the softer Superflex<sup>™</sup> fill may have some advantages in steering, braking, handling, and off-road capability, it was not selected for this test program because ARNCO recommends Superflex for tires rated at less than 50 psi and speeds less than 35 mph.

#### c. Data Acquisition Procedure

The proposed method was to mount two air-filled tires on the rear and two foam-filled tires of the same type on the front of the truck. The fully loaded armored truck was subjected to a specified series of operating conditions that tended to increase tire temperature. The air-filled and the foam-filled tire temperatures were compared during a drive-by with the use of an infrared-sensitive video camera and a thermocouple. The infrared-sensitive video camera has a color-coded temperature scale which can be used to measure and display isotherms and compare temperature differences and gradients. The location of maximum surface temperature was determined from the video isotherms. The maximum surface temperature was measured with a roving thermocouple placed at the located "hot spots."

The P-19 vehicle was driven at least 50 mph over a closed paved roadway for approximately five miles (to represent travel to the emergency site). The vehicle was stopped for three minutes (to represent firefighting and fluid discharge time). The vehicle was driven at least 50 mph for approximately five miles (to represent return for fluid refill), then stopped again for three minutes (to represent fluid refill time). This driving cycle was repeated for 2 hours (10 cycles). At the beginning of the run and at the end of each cycle, the tire maximum surface temperature was located and recorded for both the air-filled and nonpneumatic-filled tires. Temperature measurements were made in a shaped area. The vehicle was not emptied or filled at the stops but remained fully loaded throughout this test series.

It is recognized that the maximum tire or fill temperature may be internal. However, no attempt was made in this test series to measure internal tire or core temperature due to cost.

#### d. Results

TEST SERIES 1				TEST SERIES 2		
Date: 7-25-90				Date: 7-26-90		
Ambient Temp: 86.6°F Thermistor <sup>(1)</sup> 88°F Thermocouple <sup>(1)</sup>				Ambient Temp: 91°F Thermistor 93.8° Thermocouple		
Max Sidewall Surface Temp., °F				Max Sidewall Surface Temp., °F		
Cycle Time		Air-Filled Rear Tire <sup>(2)</sup> Thermistor	RePneu <sup>™</sup> Filled Front Tire <sup>(3)</sup> Thermistor	Time	Thermistor	RePneu <sup>™</sup> filled Front tires <sup>(3)</sup> Thermocouple
0	13:45	88.5	86.3	12:22	90.4	94
1	14:12	102.8	112.3	12:43	112	123
2	14:43	107.7	120.9	13:04	118.3	120
3	15:12	111.6	123.0	13:27	125.4	131
4	15:42	113.3	124.5	13:47	128.7	129
5	16:11	118.5	135.0	14:09	129.9	136
6	16:42	117.5	135.8	14:30	129.1	136
7	17:13	116.6	135.1	14:50	14.04	144
				15:04	143.1	144
				15:09 <sup>(4)</sup>	137	Max tread Surface Temp, °F <sup>(4)</sup>

- (1) In stirred ice water, Thermistor measured 32.8°F  
Thermocouple measured 36°F
- (2) Goodyear, tubeless radial, 17.5R25 AT-2A, traction type, inflated to 60 psig.
- (3) Michelin, tubeless radial, 17.5R25XL traction type, filled with ARNCO RePneu<sup>™</sup> (polyurethane) to a pressure equivalent to 70 psig air pressure.
- (4) Time required to setup infrared thermovision on tread (instead of sidewall) to find the maximum tread temperature location is suspected to have permitted some cool down.

#### e. Analysis

The P-19 vehicle was operated in cycles consisting of 5 miles at 50 mph, 3 minutes stop, 5 miles at 50 mph, 3 to 5 minute stops to take tire temperatures for each cycle. Seven cycles took about 2.5 hours to conduct on 7-26-90. On 7-25-90 about 3.5 hours were required to run 7 cycles because more exploratory time was used to locate and measure maximum surface temperatures.

Despite the high ambient temperatures, the hardened tire temperature remained well below the tire and the fill manufacture's informal temperature limits. Michelin's informal temperatures are 212°F (conservative) and 250°F (unconservative). ARNCO's RePneu™ fill informal temperature limits are 300°F (conservative) and 400°F (unconservative). Both manufacturers expressed caution and emphasized that maximum temperatures are most likely internal not at the surface. Since these were preliminary tests for comparison only of a filled-versus RePneu™ filled-tires, only surface temperatures were measured.

In general, the hardened RePneu™-filled tires ran about 18°F hotter surface temperatures than the standard air-filled tire for the cyclic operating scenario described above. A more continuous operating scenario is suspected to result in a hotter temperature difference for the hardened versus the pneumatic tire.

## 5. Suspension

### a. Objectives

(1) Measure suspension spring deformation (clearance) for the fully loaded standard and armored P-19 vehicle under static and dynamic test conditions. The standard empty vehicle suspension spring clearance were used as a reference. The intent was to check how close the axle was to the chassis hard stop. Hard stop contact (especially under dynamic conditions) was judged to be a potentially high load and stress condition for certain suspension and chassis components.

(2) Determine points of contact, interference, or damage of suspension, chassis, steering, tire and wheel wells under static deflected conditions with one wheel on an 18-inch high obstacle.

(3) Determine points of contact, interference, or damage of suspension, chassis, steering, tire and wheel wells under dynamic conditions of driving one wheel at a time over a 6-inch high curb at 10 mph.

### b. Criteria

The P-19 CFR vehicle was classified as a rough terrain vehicle. It must maintain a traction with simultaneous diagonally opposite wheel motion of 14 inches, and negotiate an 18-inch high wall.

### c. Data Acquisition Procedure

The following simplified test was performed to check for adequate clearance between the axle and the chassis. Points of contact or interference could have led to possible damage of suspension, chassis, steering, tire, and wheel wells under both static deflection conditions and simulated dynamic driving conditions. These checks were made with both a front wheel or a back wheel deflected on an 18-inch high ramp and when driven one wheel at a time over a 6-inch high curb at 10 mph. The ramp angle was approximately 24 degrees. These simplified tests were intended to provide an early indication of potential points of interference or damage as a result of adding the armor-hardening kit to the vehicle.

(1) For the empty unarmored standard truck, the clearance between the axle and the nearest contact point on the chassis in each of the four wheel positions was recorded with the truck parked on level pavement.

(2) For the standard unarmored fully loaded P-19 vehicle, the clearance between the axle and the chassis at each of the four wheels was recorded with the truck parked on level pavement.

(3) The standard fully loaded P-19 truck was driven so that the right front wheel was up a ramp 18 inches above the ground. The clearance between the axle and the chassis at all wheel positions was measured. A check was made for sufficient clearance and points of contact or interference at all suspension parts, chassis, steering mechanisms, tire, and wheel wells at all wheel positions. With the right front wheel still on the 18-inch ramp, the clearance/interference inspection at all wheel positions was repeated with the front wheels steered to the hard left and right positions.

(4) The standard fully loaded P-19 vehicle was driven on to a ramp such that only the left rear wheel was elevated 18 inches above the ground. The axle-to-chassis clearance was measured at all wheel positions. All clearance/interference inspections described in Paragraphs (2) and (3), above.

(5) The fully loaded left front and rear wheels were driven over the 6-inch high curb at 10 mph. The maximum deflection between the axle and chassis resulting from this excursion at all wheel positions was measured. This measurement was made by noting the maximum compression of modeling clay placed between the axle and chassis. This measurement technique provided data on the maximum deflection of the axle towards the chassis only. This was the most important deflection direction because of the potential hard contact between the axle and the chassis frame. After reshaping the clay, the two right wheels were driven over the 6-inch curb at 10 mph and the axle-to-chassis deflection measurements were repeated by observing the deformed clay.

(6) For the armored fully loaded P-19 fire truck, all axle-to-chassis clearance and points of contact interference/clearance inspections for the vehicle on level pavement, on the 18-inch-high ramp, and over the 6-inch high curb load conditions were repeated.

#### d. Results

##### (1) Axle-to-Chassis Clearance, $c_1$ , on Level Pavement

P-19 Vehicle Configuration	Load Condition	Axle-to-chassis clearance $c_1$ , inch			
		LF	RF	LR	RR
Standard, empty	level pavement	1.74	1.78	2.54	2.77
Standard, fully loaded	level pavement	.92	.89	1.70	1.89
Armored, fully loaded	level pavement	.71	.71	(1)	(1)

(1) No access because of armor.



(2) Axle-to-Chassis Clearance,  $c_2$ , on Static 18-inch High Ramp

P-19 Vehicle Configuration	Load Condition	Axle-to-chassis clearance $c_2$ , inch			
		LF	RF	LP	RR
Standard, fully loaded	Static 18-in. deflected RF wheel	1.75	0.30	0.58	3.07
Standard, fully loaded	Static 18-in. deflected LR wheel	2.75	0.00 <sup>(2)</sup>	2.00	2.00
Armored, fully loaded	Static 18-in. deflected RF wheel	1.47	0.00 <sup>(2)</sup>	(1)	(1)
Armored, fully loaded	Static 18-in. deflected LR wheel	2.62	0.00 <sup>(2)</sup>	(1)	(1)

(3) Axle-to-Chassis Deflection,  $d$ , Over 6-inch High Curb at 10 mph

P-19 Vehicle Configuration	Load Condition	Axle-to-chassis clearance $c_2$ , inch			
		LF	RF	LR	RR
Standard, fully loaded	6-in. curb at 10 mph, left side	0.92 <sup>(2)</sup>	(3)	1.70 <sup>(2)</sup>	(3)
Standard, fully loaded	6-in. curb at 10 mph, right side	(3)	.89 <sup>(2)</sup>	(3)	1.89 <sup>(2)</sup>
Armored, fully loaded	6-in. curb at 10 mph, left side	.71 <sup>(2)</sup>	(3)	(1)	(3)
Armored, fully loaded	6-in. curb at 10 mph, right side	(3)	.71 <sup>(2)</sup>	(3)	(1)

- \*  $d$  is + when axle displaces toward the chassis.  
 $d$  is - when axle displaces away from the chassis.  
 (1) No access because of armor.  
 (2) Axle to chassis contact.  
 (3) Not observed

(4) Contact or Interference Points

(a) Right front brake air actuator and hose contact the fender bracket when steered to the right and when there is right front axle/chassis contact. Right front or left rear tires are on an 18-inch obstacle or ramp.

(b) At the right rear there is bolt/nut interference with a fender well armor shield.

(c) At the right rear and left rear the brake drum housing has contact rubbing with fender well armor.

(d) At the right front and left front there is tire rub on the inboard armor of the fender well.

(5) These tests were by no means intended to be a replacement for proving ground rough terrain tests. It is recommended that a more complete proving ground-type test series be implemented at a later date as a separate program on the fully armored vehicle.

e. Analysis

Axle-to-Chassis Total Clearance, C, Summary; Static and Dynamic

P-19 Vehicle Configuration	Load Condition	Axle to chassis clearance, C mile			
		LF	RF	LR	RR
Standard, empty	level ground	*			
		1.74	1.78	2.54	2.77
Standard, fully loaded	level ground	0.92	0.89	1.70	1.89
Armored, fully loaded	level ground	0.71	0.71	(1)	(1)
Standard, fully loaded	Static 18-in. deflected RF wheel	1.75	0.30	0.58	3.07
Standard, fully loaded	Static 18-in. deflected LR wheel	**			
		2.75	0 <sup>(2)</sup>	2.00	2.00
Armored, fully loaded	Static 18-in. deflected RF wheel	1.47	0 <sup>(2)</sup>	(1)	(1)
Armored, fully loaded	Static 18-in. deflected LR wheel	2.62	0 <sup>(2)</sup>	(1)	(1)
Standard, fully loaded	6-in. curb at 10 mph, left side	***			
		0 <sup>(2)</sup>	(3)	0 <sup>(2)</sup>	(3)
Standard, fully loaded	6-in. curb at 10 mph, right side	(3)	0 <sup>(2)</sup>	(3)	0 <sup>(2)</sup>
Armored, fully loaded	6-in. curb at 10 mph, left side	0 <sup>(2)</sup>	(3)	0 <sup>2</sup>	(3)
Armored, fully loaded	6-in. curb at 10 mph, right side	(3)	0 <sup>(2)</sup>	(3)	0 <sup>(2)</sup>

\* For static level ground tests, measured directly,  $C = c_1$ .

\*\* For static 18-inch ramp test, measured directly,  $C = c_2$ .

\*\*\* For dynamic tests, total clearance,  $C = c_1 - d$ .

(1) No access because of armor.

(2) Hard axle to chassis contact. No damage observed.

(3) Not observed.

## 6. Vehicle Braking

### a. Objectives

The objectives of this test were to compare the stopping distance of the armor-hardened fully loaded P-19 vehicle with that of the standard fully loaded P-19 vehicle and determine if the hardened P-19 vehicle satisfies the Department of Transportation, Code of Federal Regulations, braking performance for this class vehicle.

### b. Criteria

The Department of Transportation, Code of Federal Regulations, Title 45, Federal Motor Carrier Safety Regulations, Paragraph 393.52, Brake Performance, was used as a test guide. The service brakes were tested for their capability to complete five complete successive stops within 35 feet on hard, level, smooth, dry surface free of loose material. The vehicle was not permitted to deviate from a 12-ft.-wide lane during the braking tests.

### c. Data Acquisition Procedure

The vehicle was driven at approximately 20 mph, as indicated by the vehicle's speedometer, on straight, level, dry pavement free of loose material. The brakes were applied rapidly, and the minimum distance to bring the vehicle to a complete stop was recorded. An accelerometer-based Vericom VC-200 performance computer was used to measure the stopping distance from 20 mph. The Vericom VC-200 also provided the initial speed and the time required to stop the vehicle. Either the deceleration signal or the brake light signal was used to trigger the instrument. A tape measure was used to verify the stopping distance.

### d. Results

#### (1) Standard Loaded Vehicle

Stop Number	Initial Speed, mph			Stopping Distance, ft	
	Speedometer	Vericom VC-200	Corrected Speed <sup>(4)</sup>	Vericom VC-200	Tape
1	---	24.3	---	35	35
2	20	22.5	21.3	27	25
3	18	20.2	19.4	23	21
4	16	17.8	17.7	17	17.5
5	---	21.6	---	25	---

By power law regression, brake distance, ft = 0.0266 (corrected speed, mph)<sup>2.35</sup> R<sup>2</sup> = .95 at 20 mph, brake distance = 22.7 ft.

## (2) Armored-Hardened Loaded Vehicle

Stop Number	Initial Speed, mph		Corrected Speed <sup>(4)</sup>	Stopping Distance, ft	
	Speedometer	Vericom VC-200		Vericom VC-200	Tape
1	21	---	22.5	---	31.5
2	21	---	22.5	---	33.0
3	20	---	21.5	---	22.5
4	20	---	21.5	---	26.5
5	24	---	22.50	---	38.5
6	21	---	22.5	---	31.0

By power law regression, brake distance, ft = 0.0312 (corrected speed, mph)<sup>2.21</sup> R<sup>2</sup> = .85 at 20 mph, brake distance = 23.4 ft.

<sup>(4)</sup> Speedometer indicated speed corrected to radar detector speed.

### e. Analysis

#### Average Stopping Distance

Vehicle Configuration	Average Stopping Distance from 20 mph, ft	DOT Required Stopping Distance, ft
Standard Loaded P-19	22.7	35
Armor-Hardened Loaded P-19	23.4	35

Both the armor hardened- and standard P-19 CFR vehicle satisfy the DOT requirement of successive stops from 20 mph with 35 ft.

## 7. Vehicle Acceleration on Smooth, Level Pavement

### a. Objectives

(1) Compare the zero- to 50-mph acceleration time of the armor-hardened fully loaded P-19 vehicle with that of the standard P-19 vehicle.

(2) Determine whether the armor-hardened loaded P-19 vehicle could satisfy the maximum permitted 25-second acceleration time from a complete stop to 50 mph required of the standard loaded vehicle.

b. Criteria

The standard loaded P-19 vehicle was required to accelerate from a complete stop to 50 mph in 25 seconds or less on dry, level pavement.

c. Data Acquisition Procedure

From a standing stop, the vehicle was accelerated at full throttle on a straight, level, dry pavement to 50 mph. Experimentation to obtain the optimum gear selection for this test was permitted. A radar detector (MPH Industry Inc., Model K55 Serial No. 1033) mounted in the truck cab was used to measure the vehicle speed. Time was measured with a stop watch. Three acceleration runs were conducted.

d. Results

Acceleration Time, Zero to 50 mph

STANDARD LOADED VEHICLE

Run Number	Speed, mph		Time to 50 mph, sec
	Speedometer	Radar	Stop Watch
1	48	50	21.35
2	48	50	21.37
3	48	50	21.29
Avg.			21.34

ARMOR-HARDENED LOADED VEHICLE

Run Number	Speed, mph		Time to 50 mph, sec
	Speedometer	Radar	Stop Watch
1	48	50	29.07
2	48	50	28.56
3	48	50	28.94
Avg.			28.86

e. Analysis

Vehicle Configuration	Average time 0 to 50 mph, sec	Required maximum time, sec
Standard Loaded P-19	21.34	25
Armor-Hardened Loaded P-19	28.86	N/A

The armor-hardened loaded P-19 CFR vehicle exceeds the 0 to mph maximum time requirement of 25 seconds imposed on the standard P-19 by approximately 3.9 sec. The standard loaded P-19 vehicle satisfies this requirement with a margin of about 3.7 seconds.

8. Vehicle Handling

a. Objectives

(1) Verify that both the standard and armor-hardened fully loaded vehicle configurations could satisfy the wall-to-wall vehicle clearance circle of 80 feet or less.

(2) Compare the handling and cornering of the armor-hardened loaded P-19 vehicle with that of the standard loaded P-19 vehicle to evaluate if there were any deterioration in handling as a result of the added armor kit weight.

b. Criteria

(1) The vehicle wall-to-wall clearance circle must be 80 feet in diameter, or less.

(2) There shall be no specific cornering or handling criteria on a short course specified; consequently, handling and cornering comparisons between the standard loaded P-19 vehicle and the armor loaded P-19 vehicle were accomplished on an arbitrarily selected short, slow-speed obstacle course described below. This short obstacle course was intended only to provide a preliminary comparison of the handling and cornering of the two P-19 vehicle configurations.

c. Acquisition Procedure

(1) The P-19 vehicle was driven slowly in a left turn circular pattern with the steering wheel in a full left position. The center of a safety cone was used to mark the extremity of the vehicle at the extreme ends of the turning circle diameter. A tape was used to measure the distance between the center line of the cones. The test was repeated with a hard right turning circle.

(2) Vehicle handling and cornering were evaluated by an experienced P-19 operator on a timed obstacle course on smooth, level pavement. The approximate obstacle course was laid out with safety cones on a smooth, paved parking lot. The course was adjusted to assure that all turns could be negotiated by the P-19 vehicle. The basic course was a small figure eight

permitting relatively slow speed traverses. Lap times were measured with a stopwatch in both directions. The handling comparison of the standard and armor-hardened vehicles were determined by timed traverses of the obstacle course and by the subjective evaluation of the driver.

#### d. Results

##### (1) Wall-to Wall Turning Circle

Vehicle Configuration	Turning Circle Diameter, ft	
	Left	Right
Standard Loaded P-19	79.0	75.1
Armor-Hardened Loaded P-19	77.8	76.8

##### (2) Timed Obstacle Course

Lap Number	Three Fastest Lap Times to Traverse Obstacle Course, sec			
	Standard Loaded P-19		Armored Loaded P-19	
	CW	CCW	CW	CCW
1	37.02	36.81	38.02	39.06
2	36.24	36.68	37.56	39.14
3	36.31	37.47	37.76	39.15
Avg.	36.52	36.99	37.78	39.12
	3-28-90	3-27-90	7-23-90	7-23-90

#### e. Analysis

##### (1) Objective Vehicle Handling

	Standard Loaded P-19	Armored Loaded P-19
Average Turning Circle, ft	77.1	77.3
Average of Three Best Times Over Obstacle Courses, sec	36.76	38.45

The armored loaded P-19 is about 5 percent slower over the obstacle course than the standard P-19.



## (2) Subjective Vehicle Handling

Driver Comments: Acceleration and braking was noticeably slower in the Armored P-19. Differences in vehicle steering and cornering were not very noticeable.

## 9. Armor-Hardening Kit Installation

### a. Objectives

(1) Assure the correct parts and instruction manual are provided such that Air Force personnel without special training can install the armor-hardening kit using only tools expected to be available in the field and/or included as part of the kit.

(2) Determine the ease or difficulty of installation and the time required to install the hardening kit.

(3) Inspect the installed kit for adequacy of the kit's design, configuration, and fit.

### b. Criteria

The armor-hardening kit must be easily installed by Air Force personnel (who may not necessarily be specially trained) using the parts and instruction manual provided in the kit and using only tools and equipment which are readily available in the field.

### c. Data Acquisition Procedure

(1) The armor kit was provided in marked crates along with a written installation instruction manual to Air Force personnel who were inexperienced and unfamiliar with the armor-hardening kit. Air Force personnel used special kit tools, standard mechanic's hand tools, and other equipment which the Air Force would normally have available in the field. The Air Force crew installed the armor kit on the truck. The difficulty or ease that was encountered and the time required to install the kit was recorded and documented by observers using video recorders, voice recorders, photographs, and written notes.

(2) After installation was completed, the armor was inspected by Air Force and ORNL personnel for adequacy of the kit's design, armor configuration, and fit. Observations were recorded by videotape, voice tape, photographs, and written notes.

### d. Results

This information is included in the hardening kit installation procedures at Appendix A.

### e. Analysis

Observations based on this installation exercise should be used to modify the armor kit, alter the suggested field tool list, or modify the installation instructions.

## 10. Equipment Access and Operability

### a. Objective

Assure accessibility to functional portions of the P-19 CFR vehicle with the armor-hardening kit installed.

### b. Criteria

(1) The installed armor-hardened kit shall not significantly impair the accessibility, functionality, and operability, of the firefighting systems and equipment of the P-19 CFR vehicle. Access and operability of the hardened P-19 vehicle shall not be significantly different from the access and operability of the standard P-19 vehicle.

(2) Access to daily liquid level checks and daily maintenance checkpoints shall not be excessively impaired by the installation of the armor-hardening kit.

### c. Data Acquisition Procedure

The equipment access and operability of the firefighting systems of the truck and daily maintenance and check portions of the truck were evaluated for the armor-hardened fully loaded truck. The access and operability checks were made with the vehicle parked on level pavement and also checked with the vehicle parked with the right front wheel on an 18-inch-high ramp. Accessibility was checked again with the left rear wheel on an 18-inch-high ramp. This put the vehicle chassis and body in a distorted shape where latches and accessibility into compartments could be evaluated under these extreme deformations. Access to daily maintenance and fluid check portions of the engine compartment and other parts of the vehicle were done with the P-19 CFR parked on a level, paved surface. Experienced firefighting personnel familiar with the P-19 CFR vehicle made an objective evaluation of equipment accessibility and operability. Their observations, comments, and criticisms were recorded and documented by means of video recorders, voice recorders, photographs, and written notes.

### d. Results

The hardening kit limits access to some periodic maintenance locations on the vehicle such as the engine compartment, drive train, and under body areas of the truck. These limitations are incorporated in the kit installation procedures at Appendix A.

## SECTION III

### CONCLUSIONS AND RECOMMENDATIONS

#### A. CONCLUSIONS

The results of this project indicate that it is feasible to armor a P-19 crash-rescue vehicle to provide protection to the vehicle and its occupants from postattack hazards. The proposed method for accomplishing this is to have a hardening kit available for each vehicle which is at risk. The kit, designed to allow the vehicle to survive with 95 percent probability 100 random events using the NATO Standard Fragment Threat Criteria, will consist of steel panels, Lexan<sup>™</sup> transparent panels, flexible Kevlar 29<sup>™</sup> panels, the appropriate fasteners for attaching the panels, and a set of spare wheels with tires filled with ARNCO RePneu<sup>™</sup> water-based polyurethane foam. The details for the components of such a kit are given in drawings MIE-T-1530-A through MIE-T-1548. The details of the packing boxes for the kit are given in drawings MIE-T-1549 through MIE-T-1556.

The weight of the armor is approximately 2,927 pounds and the weight from the foam tire fill is approximately 2,973 pounds resulting in a total armor kit weight of approximately 5,900 pounds. This additional weight will have a minimal effect upon the vehicle.

In summary, it is believed that the use of the hardening kit will greatly enhance the safety of the firefighter and better enable him to perform his/her mission in a postattack environment.

#### B. RECOMMENDATIONS

P-19 firefighting vehicles should be modified with the armor attachment points. Armor kits should be procured and located with WRM stocks, ready for wartime use. With the proper degree of threat, the armor kit would be installed, per the installation procedure provided in Appendix A, and left on the vehicle until the danger of debris, unexploded bombs, and munitions is past.

Complete drawings are available in hard copy and as Autocad drawings on computer disk through AFCESA/DF.

**APPENDIX A**  
**P-19 FIRE VEHICLE HARDENING KIT**  
**INSTALLATION PROCEDURES**

**A. PURPOSE OF KIT**

The purpose of this kit is to provide a means for protecting the P-19 vehicle and its operating personnel from many of the hazards existing after an attack. It is intended to enable the fire fighters to conduct their mission with a much greater degree of safety from the dangers associated with unexploded munitions and other obstacles.

**B. KIT DEPLOYMENT**

Present plans call for a kit to be assigned to each operational P-19. Modifications to the P-19, which allow for the kit installation, must be completed prior to the installation of the kit. These vehicle modifications are not covered in these instructions. The kit is to be installed when directed by the commander or his designated representative.

**C. PART NUMBER AND VEHICLE LOCATION NUMBERING SYSTEM**

1. All part names and numbers are taken from the drawings titled "Fire Vehicle P19 Hardening," numbered MIE-T-1530 TO MIE-T-1555. These drawings are the property of the Air Force Civil Engineering Support Agency.

2. All parts are labeled on the inside as follows:

- a. NAME
- b. PART NUMBER
- c. LOCATION ON VEHICLE.
- d. ANY SPECIAL INSTRUCTIONS THAT MAY BE REQUIRED FOR THAT PART.

3. Where a double part number series for one part exists, it implies multiple parts, i.e., one each for the driver side and crew chief side, T-1542-2 and T-1542-3 represent the front bumper covers for the driver's and crew chief's side, respectively.

4. Some multiple parts have a single part number, indicating interchangeable. For example, T-1537-3, cab door window (Lexan<sup>™</sup>) (there are two) are interchangeable and may be used on either side.

5. Vehicle locations are as follows:

- 1. FRONT
- 2. CAB, CREW CHIEF SIDE
- 3. CAB, DRIVER SIDE
- 4. MIDDLE, CREW CHIEF SIDE
- 5. MIDDLE, DRIVER SIDE
- 6. ENGINE, CREW CHIEF SIDE
- 7. ENGINE, DRIVER SIDE
- 8. ENGINE, REAR

9. BELLY, FRONT
10. BELLY, AXLE FRONT
11. BELLY, MIDDLE
12. BELLY, AXLE REAR
13. BELLY, REAR
14. WHEEL WELL, CREW CHIEF FRONT
15. WHEEL WELL, DRIVER FRONT
16. WHEEL WELL, CREW CHIEF REAR
17. WHEEL WELL, DRIVER REAR

**D. LIST OF DRAWINGS**

<u>DRAWING NO.</u>	<u>TITLE OF DRAWING</u>
1530	Cover Sheet
1530-A	Fire Truck Panels Assembly (Left Side, Front and Rear
1530-B	View and Details
1531-A	Fire Truck Panels Assembly (Right Side, Bottom View
1531-B	Sections & Views of Air Connection
1532	Fire Vehicle Panel Details
1533	Fire Vehicle Panel Details
1534	Fire Vehicle Plating Details
1535	Fire Vehicle Plating Details
1536	Fire Vehicle Plating Details
1537	Fire Vehicle Panel Details
1538	Fire Vehicle Panel Details
1539	Fire Vehicle Panel Details
1540	Fire Vehicle Panel Details
1541	Fire Vehicle Plating Details
1542	Fire Vehicle Panel Details
1543	Fire Vehicle Panel Details
1544	Fire Vehicle Panel Details
1545	Fire Vehicle Plating Details
1546	Fire Vehicle Plating Details

1547	Fire Vehicle Plating Details
1548	Fire Vehicle Panel Details
1549	Shipping Crate #1
1550	Shipping Crates #2 and #4
1551	Shipping Crate #3
1552	Shipping Crate #5
1553	Shipping Crates #6 and #7
1554	Shipping Crates #8 and #3
1555	Shipping Crate #10

**E. TOOLS AND EQUIPMENT REQUIRED**

JACKS - MINIMUM 20 TON, HYDRAULIC 2 TON FLOOR JACK WITH HIGH REACH  
20 INCH MINIMUM

AIR TOOLS - AIR RATCHET, 3/4 INCH IMPACT WRENCH  
AIR RATCHET, 1/2 INCH IMPACT WRENCH

SOCKETS AND DRIVES -  
STANDARD SAE 3/8 INCH THROUGH  
1 1/2 INCH FOR 1/2 INCH DRIVE.  
STANDARD SAE 1 3/4 FOR 3/4 INCH DRIVE.  
LUG WRENCH, 1 3/4 INCH FOR P-19  
STANDARD SAE 3/8 INCH DRIVE SET.

WRENCHES - ONE SET OPEN/CLOSED END WRENCHES

PIPE STEEL - 3 FOOT MIN

PRY-BAR - 3 FOOT MIN

FORK-LIFT - 4-ton

HAMMERS - CLAW 1  
BALL-PEEN 1

OIL - WD-40 TYPE  
AIR WRENCH

CREEPER - 2 ea

CRIBBING - OF SUFFICIENT SIZE AND STRENGTH TO SUPPORT VEHICLE

SCREWDRIVERS - ASSORTED

LIGHTS - DROP TYPE, 110 OR 24 VOLT FOR VEHICLE SYSTEM  
FLASHLIGHT WITH BATTERIES.

**F. CONTENTS OF KIT CONTAINERS**

**CONTAINER # 1  
PARTS LISTING**

T-1539-1 FRONT BELLY PANEL  
T-1539-2 MIDDLE BELLY PANEL  
T-1539-3 REAR BELLY PANEL  
T-1548-3A BRACKET  
T-1548-3 BRACKET  
T-1548-1 BRACKET  
T-1548-2 BRACKET  
T-1548-1 BRACKET  
T-1548-3 BRACKET  
T-1548-3A BRACKET  
T-1542-1 SKID PANEL, FRONT LOWER  
T-1532-2 SKID PANEL, FRONT MIDDLE  
T-1532-1 SKID PANEL, FRONT UPPER  
HARDWARE BOLT 5/16-18X1" 64 EA  
HARDWARE WASHER 5/16X7/8OD 130 EA  
HARDWARE NUTS 5/16-18 66 EA

**CONTAINER #2  
PARTS LISTING**

T-1533-1 FRONT BELLY PLATE  
T-1532-3 MOUNTING BRACKET  
T-1532-3 MOUNTING BRACKET  
T-1547-1 FLEXIBLE CONNECTOR, FRONT  
T-1547-4 FLEXIBLE CONNECTOR, FRONT  
T-1533-2 REAR BELLY PLATE  
T-1532-3 MOUNTING BRACKET  
T-1532-3 MOUNTING BRACKET  
T-1547-2 FLEXIBLE CONNECTOR  
T-1547-3 FLEXIBLE CONNECTOR  
HARDWARE BOLT 5/16-18 X 1" 11 EA  
HARDWARE WASHER 5/16 X 7/8OD 45 EA  
HARDWARE BOLT 5/16-18 X 2" 24 EA  
HARDWARE NUT 3/4-16 18 EA  
HARDWARE NUT 1/2-13 10 EA  
HARDWARE NUT 5/16-18 10 EA  
HARDWARE NUT 7/8-14 5 EA  
HARDWARE WASHER 7/8 X 3/4OD 5 EA

**CONTAINER # 3**  
**PARTS LISTING**

T-1534-5	HALON TANK BRACKET
T-1534-5	HALON TANK BRACKET
T-1547-5	FLEXIBLE CONNECTOR (KEVLAR <sup>tm</sup> )
T-1547-5	FLEXIBLE CONNECTOR (KEVLAR <sup>tm</sup> )
T-1543-2	HALON TANK PANEL
T-1543-1	HALON TANK PANEL
T-1541-3	REAR TANK PANEL UPPER LEFT
T-1537-1	UPPER ENGINE PANEL
T-1534-1	LOWER REAR ENGINE LEFT SIDE
T-1536-1	RADIATOR COVER
T-1541-4	REAR TANK PANEL UPPER RIGHT
T-1537-2	UPPER ENGINE PANEL
T-1537-6	LOWER REAR ENGINE PANEL
HARDWARE	BOLT 1 X 5/16-18 55 EA
HARDWARE	WASHER 5/16 X 7/8OD 80 EA
HARDWARE	BOLT 1 3/4 X 5/16-18 10 EA
HARDWARE	BOLT 2 X 5/16-18 11 EA
HARDWARE	BOLT 1/4-20 5 EA
HARDWARE	WASHER 3/8 X 20D 10 EA
HARDWARE	WASHER 1/4 X 1/2 OD 5 EA

**CONTAINER # 4**  
**PARTS LISTING**

T-1545-3	WINDOW BRACKET
T-1545-4	WINDOW BRACKET
T-1536-4	FRONT GUARD
T-1536-4	FRONT GUARD
T-1542-3	FRONT BUMPER COVER
T-1542-2	FRONT BUMPER COVER
T-1538-2	CENTER FRONT BUMPER COVER
T-1533-4	COMPARTMENT PANEL UPPER FRONT
T-1533-4	COMPARTMENT PANEL UPPER FRONT
T-1538-3	COMPARTMENT PANEL LOWER FRONT
T-1533-3	COMPARTMENT PANEL LOWER FRONT
T-1538-4	COMPARTMENT PANEL LOWER REAR
T-1538-4	COMPARTMENT PANEL LOWER REAR
T-1533-3	COMPARTMENT PANEL UPPER REAR
T-1533-3	COMPARTMENT PANEL UPPER REAR
T-1535-3	LOWER LATCH BAR
T-1535-3	LOWER LATCH BAR
T-1541-2	LATCH BAR
T-1535-4	LATCH BAR
T-1543-4	LATCH BAR
T-1535-2	LATCH BAR
T-1541-1	LATCH BAR
T-1535-1	LATCH BAR
T-1535-5	LATCH BAR
T-1543-3	LATCH BAR
HARDWARE	BOLT 1/2 X 5/16-18 11 EA
HARDWARE	BOLT 1 X 5/16-18 21 EA
HARDWARE	BOLT 1 1/2 X 5/16-18 68 EA



HARDWARE WASHER 5/16 X 7/8OD 100 EA  
HARDWARE BOLT 1/4-20 70 EA  
HARDWARE WASHER 1/4 X 1/2OD 70 EA

**CONTAINER # 5  
PARTS LISTING**

T-1537-5 FRONT CAB AREA PANEL  
T-1540-2 DOOR STEP PANEL  
T-1536-6 CAB DOOR PANEL  
T-1534-3 CAB AREA PANEL  
T-1537-4 FRONT CAB AREA PANEL  
T-1540-1 DOOR STEP PANEL  
T-1536-5 CAB DOOR PANEL  
T-1534-4 CAB AREA PANEL  
T-1538-1 REAR BUMPER GUARD  
HARDWARE BOLT 1 X 5/16-18 80 EA  
HARDWARE BOLT 1 1/2 X 5/16-18 3 EA  
HARDWARE WASHER 5/16 X 7/8OD 83 EA

**CONTAINER # 6  
PARTS LISTING**

T-1545-7 WHEEL WELL PANEL FRONT RIGHT  
T-1542-6 WHEEL WELL PANEL FRONT RIGHT  
T-1544-6 WHEEL WELL PANEL FRONT RIGHT  
T-1546-3 WHEEL WELL PANEL FRONT RIGHT  
T-1544-4 WHEEL WELL PANEL FRONT RIGHT  
T-1540-6 WHEEL WELL PANEL FRONT RIGHT  
T-1546-4 WHEEL WELL PANEL FRONT RIGHT  
T-1540-4 WHEEL WELL PANEL FRONT RIGHT  
HARDWARE BOLT 1 X 5/16-18 36 EA  
HARDWARE WASHER 5/16 X 7/8OD 36 EA

**CONTAINER # 7  
PARTS LISTING**

T-1545-6 WHEEL WELL PANEL FRONT LEFT  
T-1542-5 WHEEL WELL PANEL FRONT LEFT  
T-1544-5 WHEEL WELL PANEL FRONT LEFT  
T-1540-5 WHEEL WELL PANEL FRONT LEFT  
T-1540-3 WHEEL WELL PANEL FRONT LEFT  
T-1545-5 WHEEL WELL PANEL FRONT LEFT  
T-1544-3 WHEEL WELL PANEL FRONT LEFT  
HARDWARE BOLT 1 X 5/16-18 37 EA  
HARDWARE WASHER 5/16 X 7/8OD 37 EA

**CONTAINER # 8  
PARTS LISTING**

T-1545-1	WHEEL WELL PANEL REAR LEFT
T-1544-1	WHEEL WELL PANEL REAR LEFT
T-1546-5	WHEEL WELL PANEL REAR LEFT
T-1541-5	WHEEL WELL PANEL REAR LEFT
T-1544-7	WHEEL WELL PANEL REAR LEFT
T-1546-1	WHEEL WELL PANEL REAR LEFT
HARDWARE	BOLT 1 X 5/16-18 25 EA
HARDWARE	WASHER 5/16 X 7/8OD 25 EA

**CONTAINER # 9  
PARTS LISTING**

T-1541-6	WHEEL WELL PANEL RIGHT REAR
T-1546-6	WHEEL WELL PANEL RIGHT REAR
T-1545-2	WHEEL WELL PANEL RIGHT REAR
T-1544-2	WHEEL WELL PANEL RIGHT REAR
T-1546-2	WHEEL WELL PANEL RIGHT REAR
T-1544-8	WHEEL WELL PANEL RIGHT REAR
HARDWARE	BOLT 1 X 5/16-18 25 EA
HARDWARE	WASHER 5/16 X 7/8OD 25 EA

**CONTAINER # 10  
PARTS LISTING**

T-1540-7	WINDSHIELD EXTENSIONS (2)
T-1542-4	HEADLIGHT COVER (LEXAN <sup>tm</sup> )
T-1542-4	HEADLIGHT COVER (LEXAN <sup>tm</sup> )
T-1534-2	WINDSHIELD PANEL (LEXAN <sup>tm</sup> )
T-1537-3	CAB DOOR WINDOW (LEXAN <sup>tm</sup> )
T-1537-3	CAB DOOR WINDOW (LEXAN <sup>tm</sup> )
T-1536-3	DOOR WINDOW PANEL (LEXAN <sup>tm</sup> )
T-1536-2	DOOR WINDOW PANEL (LEXAN <sup>tm</sup> )
HARDWARE	BOLT 2 X 5/16-18 10 EA
HARDWARE	BOLT 2 1/2 X 5/16-18 46 EA
HARDWARE	BOLT 1/4-20 7 EA
HARDWARE	WASHER 3/8 X 20D 63 EA

**G. OVERALL ORDER OF INSTALLATION**

This section describes the overall order of installation and general installation procedures. By following these general instructions and the detailed installation instructions contained in paragraph H, the installation of the hardening kit should flow smoothly.

**1. ORDER OF INSTALLATION**

BELLY, MIDDLE  
BELLY, REAR  
BELLY, FRONT

BELLY, AXLE REAR  
BELLY, AXLE FRONT  
WHEEL AND WHEEL WELL ARMOR  
1. FRONT, DRIVER AND CREW CHIEF SIDE  
2. REAR, DRIVER AND CREW CHIEF SIDE  
FRONT CAB - DRIVER SIDE  
FRONT CAB - CREW CHIEF SIDE  
MIDDLE SECTION - DRIVER SIDE  
MIDDLE SECTION - CREW CHIEF SIDE  
ENGINE - DRIVER SIDE  
- CREW CHIEF SIDE  
ENGINE - REAR

## 2. GENERAL INSTALLATION INSTRUCTIONS

The following general installations instructions are in recommended sequence by vehicle area.

### BELLY -- MIDDLE

#### CONTAINER # 1

1. INSTALL BRACKETS TO SUPPORT BELLY PLATES. STARTING FRONT WORKING TO REAR:
  - A. T-1548-1
  - B. T-1548-2
  - C. T-1548-3
2. ATTACH BELLY PLATES TO BRACKETS STARTING FORWARD AND WORKING TOWARDS REAR:
  - A. T-1539-1, BELLY PANEL FRONT
  - B. T-1539-2, BELLY PANEL MIDDLE

NOTE - PANEL TO BE MOUNTED WITH  
TWO DOOR PINS OF EITHER SIDE ON  
TOP SIDE.

- C. T-1539-3, BELLY PANEL REAR

### BELLY -- REAR

#### CONTAINER #5

1. INSTALL REAR BUMPER GUARD, T-1538-1

### BELLY -- FRONT

#### CONTAINER #1

1. INSTALL LOWER SKID PANEL, T-1542-1
2. INSTALL MIDDLE SKID PANEL, T-1532-2
3. INSTALL UPPER SKID PANEL, T-1532-1

## **BELLY -- AXLE REAR**

### **CONTAINER #2**

1. INSTALL MOUNTING BRACKETS, T-1532-3 TO REAR AXLE U-BOLT WITH ANGLE IRON TO VEHICLE CENTER WITH SHORT SECTION TO FRONT OF VEHICLE.
2. ATTACH FLEXIBLE CONNECTOR (KEVLAR<sup>tm</sup>) TO REAR BELLY PANEL, T-1533-2. USE ALUMINUM MOUNTING BRACKETS TO SUPPORT WASHERS AND SCREWS AGAINST KEVLAR<sup>tm</sup>.\*

\* COMPLETE PRIOR TO INSTALLATION OF REAR BELLY PANEL.

- A. ATTACH FLEXIBLE CONNECTOR, KEVLAR<sup>tm</sup>, T-1547-2 WITH THREE FORWARD MOUNTING HOLES ATTACHES TO FORWARD EDGE OF REAR BELLY PANEL.
  - B. FLEXIBLE CONNECTOR (KEVLAR<sup>tm</sup>) T-1547-4 WITH SIX REAR MOUNTING HOLES ATTACHES TO THE REAR EDGE OF REAR BELLY PANEL.
3. INSTALL REAR BELLY PLATE, T-1533-2 TO MOUNTING BRACKET.
  4. ATTACH REMAINING FLEXIBLE CONNECTOR SIDES (KEVLAR<sup>tm</sup>).
    - A. REAR KEVLAR<sup>tm</sup> ATTACHES TO REAR BUMPER GUARD.
    - B. FRONT KEVLAR<sup>tm</sup> ATTACHES TO BELLY SUPPORT BRACKET.

## **BELLY -- AXLE FRONT**

### **CONTAINER #1 AND #2**

1. INSTALL MOUNTING BRACKET, T-1532-3 TO FRONT AXLE U-BOLT WITH ANGLE IRON TO VEHICLE CENTER AND SHORT SECTION TO FORWARD.
2. ATTACH FLEXIBLE CONNECTOR (KEVLAR<sup>tm</sup>) TO FRONT BELLY PANEL, T-1533-1. USE ALUMINUM BRACKETS TO SUPPORT WASHERS AND SCREWS AGAINST KEVLAR<sup>tm</sup>.
  - A. COMPLETE THIS PRIOR TO INSTALLING FRONT BELLY PANEL.
  - B. KEVLAR<sup>tm</sup> PANEL T-1547-1 WITH FOUR FORWARD SCREW SUPPORTS ATTACHES TO FRONT OF BELLY PANEL.
  - C. KEVLAR<sup>tm</sup> PANEL T-1547-4 WITH THREE REAR SCREW SUPPORTS ATTACHES TO REAR OF BELLY PANEL.
3. INSTALL FRONT BELLY PANEL, T-1533-1 TO PREVIOUSLY INSTALLED MOUNTING BRACKETS.
4. ATTACH REMAINING FLEXIBLE CONNECTOR (KEVLAR<sup>tm</sup>) SIDES.
  - A. REAR KEVLAR<sup>tm</sup> ATTACHES TO FRONT BELLY SUPPORT BRACKET.
  - B. FRONT KEVLAR<sup>tm</sup> ATTACHES TO LOWER SKID PANEL.

## **WHEEL AND WHEEL WELL ASSEMBLY**

### **CONTAINER # 7 DRIVER SIDE FRONT**

1. REMOVE CONVENTIONAL WHEEL/TIRE.

#### **INSTALL WHEEL WELL ARMOR**

A. T-1544-5

B. T-1544-3

C. T-1542-5

D. T-1545-6

E. T-1545-5

F. T-1540-3

(1) INSTALL AFT OF AXLE ON FRONT BELLY PANEL.

G. T-1540-5

(1) INSTALL FORWARD OF AXLE ON FRONT BELLY PANEL.

3. INSTALL BRAKE LINE PROTECTION.

4. INSTALL HARDENED WHEEL/TIRE.

## **WHEEL AND WHEEL WELL ASSEMBLY**

### **CONTAINER # 6, FRONT CREW CHIEF SIDE.**

1. REMOVE CONVENTIONAL WHEEL/TIRE.

2. INSTALL WHEEL WELL ARMOR.

A. T-1546-4

(1) INSTALLS FORWARD OF AXLE

B. T-1544-6

C. T-1544-4

D. T-1546-3

E. T-1542-6

F. T-1545-7

G. T-1540-6

(1) INSTALL FORWARD OF AXLE ON FRONT BELLY PANEL.

H. T-1540-4

(1) INSTALL AFT OF AXLE ON FRONT BELLY PANEL.

3. INSTALL BRAKE LINE PROTECTION.

4. INSTALL HARDENED WHEEL/TIRE.

## **WHEEL AND WHEEL WELL ASSEMBLY**

### **CONTAINER # 8, DRIVER SIDE, REAR**

1. REMOVE CONVENTIONAL WHEEL/TIRE.
2. INSTALL WHEEL WELL ARMOR.
  - A. T-1544-7
  - B. T-1544-1
  - C. T-1546-1
  - D. T-1545-1
  - E. T-1541-5
  - F. T-1546-5(1) ATTACH TO REAR BELLY PANEL
3. INSTALL HARDENED WHEEL/TIRE.

## **WHEEL AND WHEEL WELL ASSEMBLY**

### **CONTAINER # 9, CREW CHIEF SIDE, REAR**

1. REMOVE CONVENTIONAL WHEEL/TIRE.
2. INSTALL WHEEL WELL ARMOR.
  - A. T-1544-8
  - B. T-1544-2
  - C. T-1546-2
  - D. T-1545-2
  - E. T-1541-6
  - F. T-1546-6(1) ATTACH TO REAR BELLY PANEL.
3. INSTALL HARDENED WHEEL/TIRE.

## **FRONT**

### **CONTAINER #4 AND #10**

1. REMOVE WIPER ARMS
2. REMOVE ONE (1) SPOTTER MIRROR FROM MIRROR MOUNT. LEAVE MOUNT ATTACHED TO VEHICLE.
3. INSTALL FRONT GUARD, T-1536-4
4. INSTALL LEXAN<sup>™</sup> WINDSHIELD, T-1534-2.
5. REATTACH SPOTTER MIRROR TO MIRROR MOUNT.
6. INSTALL WIPER EXTENSIONS, T-1540-7. ONE TO DRIVER SIDE AND ONE TO C/C SIDE.
7. ATTACH WIPER ARMS TO EXTENSIONS.

8. INSTALL FRONT BUMPER GUARD COVERS TO DRIVER AND C/C SIDE, T-1542-3, AND T-1542-2.
9. INSTALL FRONT BUMPER COVER TO CENTER, T-1538-2.
10. INSTALL LEXAN<sup>™</sup> HEADLIGHT COVERS, T-1542-4.

**CAB -- SIDES, DRIVER AND CREW CHIEF**

CONTAINER #3, #4, #5, #10

1. REMOVE HANDHOLDS FROM CAB SIDES.
2. REMOVE BOLT, SPRING AND NUT FROM BOTTOM PORTION OF REARVIEW MIRROR MOUNTS.
3. INSTALL CAB SIDE ARMOR.

T-1540-1/2 DOOR STEP PANELS

T-1537-4/5 FRONT CAB AREA PANELS

T-1536-5/6 CAB DOOR PANELS

\* NOTE - SOME EXISTING VEHICLE SCREWS WILL BE UTILIZED.

4. RE-INSTALL BOLT, SPRING AND NUT TO BOTTOM PORTION OF REAR VIEW MIRROR MOUNTS. ATTACH WITH SPRING AND NUT TO BOTTOM SIDE OF THE MOUNT.
5. INSTALL DOOR WINDOW PANEL (LEXAN<sup>™</sup>) T-1536-2.
6. INSTALL WINDOW BRACKET T-1545-3 AND T-1545-4 TO DOOR WINDOW FRAMES.
7. INSTALL CAB DOOR WINDOW, (LEXAN<sup>™</sup>), T-1537-3. (FORWARD SIDE WINDOW)
8. INSTALL T-1534-3/4, CAB AREA PANELS.
9. INSTALL T-1534-5, HALON TANK BRACKETS WITH ATTACHED FLEXIBLE CONNECTOR (KEVLAR<sup>™</sup>).
10. ATTACH KEVLAR<sup>™</sup> TO CAB AREA PANEL PREVIOUSLY INSTALLED. USE MINIMUM 2-INCH WASHERS. INSURE THAT ALUMINUM SUPPORT BRACKETS ARE ATTACHED TO KEVLAR<sup>™</sup>.
11. INSTALL T-1543-1/2, HALON TANK PANELS.

## **MIDDLE - DRIVER AND CREW CHIEF SIDES**

### **CONTAINER #4**

1. INSTALL T-1543-3/4, LATCH BARS, TO LOWER REAR DOOR FRAMES.
2. INSTALL T-1535-1/4, LATCH BARS, TO LOWER FRONT DOOR FRAMES.
3. INSTALL T-1535-2/5, LATCH BARS, TO UPPER REAR DOOR FRAMES.
4. INSTALL T-1541-1/2, LATCH BARS, TO UPPER FRONT DOOR FRAMES.
5. INSTALL T-1535-3, LATCH BAR-CENTER, JUST ABOVE LOWER CENTER COMPARTMENT DOOR. (SAME PART NUMBER FOR BOTH SIDES.)
6. INSTALL COMPARTMENT PANELS:

T-1533-3 UPPER REAR DRIVER AND C/C T-1533-4 UPPER FRONT DRIVER AND C/C  
T-1538-3 LOWER FRONT DRIVER AND C/C T-1538-4 LOWER REAR DRIVER AND C/C.

## **ENGINE -- SIDE, DRIVER AND CREW CHIEF**

### **CONTAINER #3**

1. INSTALL T-1537-6 AND T-1534-1, LOWER REAR ENGINE PANELS.
2. INSTALL T-1537-2/1, UPPER ENGINE PANELS.
3. INSTALL T-1541-3/4, REAR TANK PANELS.

## **ENGINE -- REAR**

CONTAINER #3 1. INSTALL T-1536-1, RADIATOR COVER.



## H. DETAILED INSTALLATION INSTRUCTIONS

The kit is to be installed using the tools provided in the kit and the additional tools listed under paragraph E, Tools and Equipment Required. Component sizes and weights are shown in Table A-1. Diagrams and photographs of the P-19, both with and without the hardening kit installed are shown in Figures A-1 through A-8.

Table A-1. P-19 Hardening Kit Component Sizes and Weights

<u>PANEL LOCATION</u>	<u>THICKNESS (INCHES)</u>	<u>AREA (SQUARE FEET)</u>	<u>WEIGHT (POUNDS)</u>
Bottom Panel	0.1875	78.3	598.9
Front Window	0.125	15.1	77.0
Right Side Window	0.125	6.9	35.2
Left Side Window	0.125	6.9	35.2
Upper Front Panel	0.125	20.7	105.6
Lower Front Panel	0.1875	39.3	300.6
Radiator Grill	0.125	22.8	116.3
Right Side Engine	0.125	21.6	110.2
Left Side Engine	0.125	21.6	110.2
Upper Right Side Panel	0.125	10.8	55.1
Lower Right Side	0.15	18.9	115.7
Right Side Cab	0.125	24.8	126.5
Left Side Cab	0.125	24.8	126.5
Upper Left Side	0.125	10.8	55.1
Lower Left Side	0.15	18.9	115.7
Totals		342.2	2,083.8

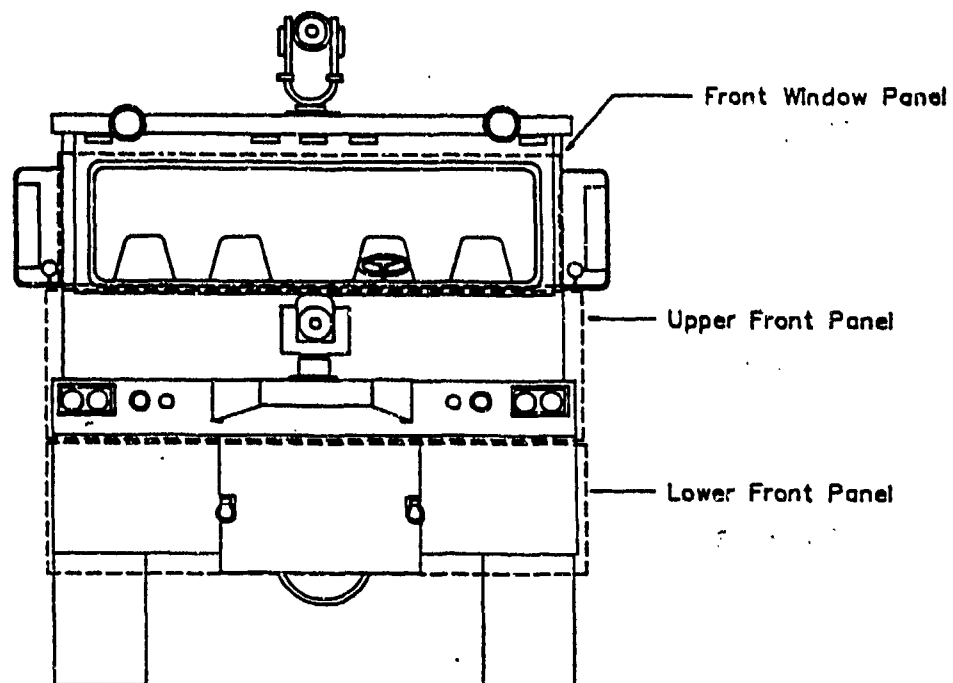


Figure A-1. Target Panels, Front

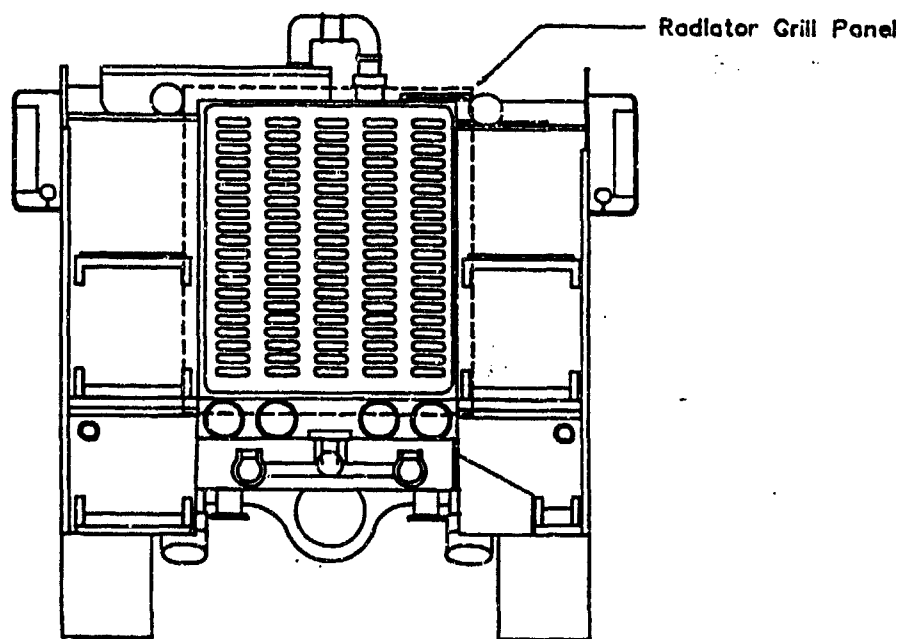


Figure A-2. Target Panels, Rear

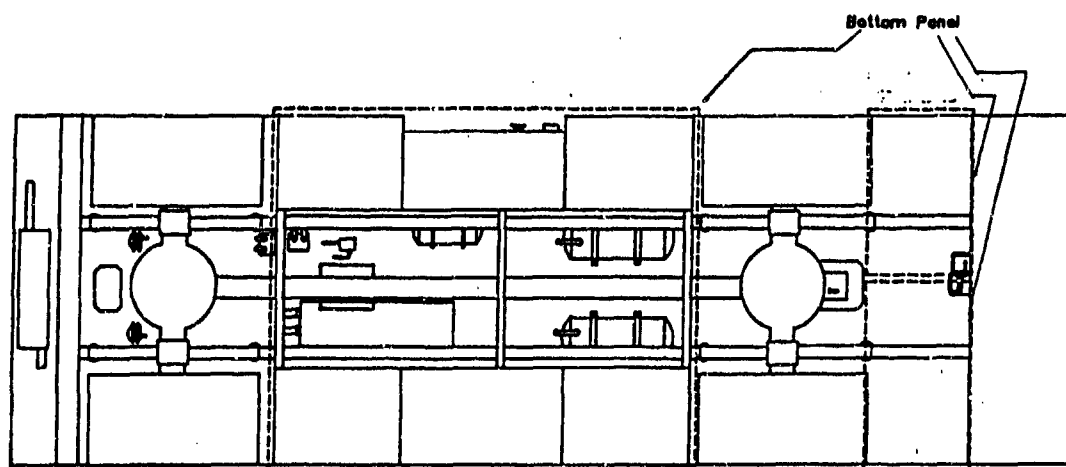


Figure A-3. Target Panels, Bottom

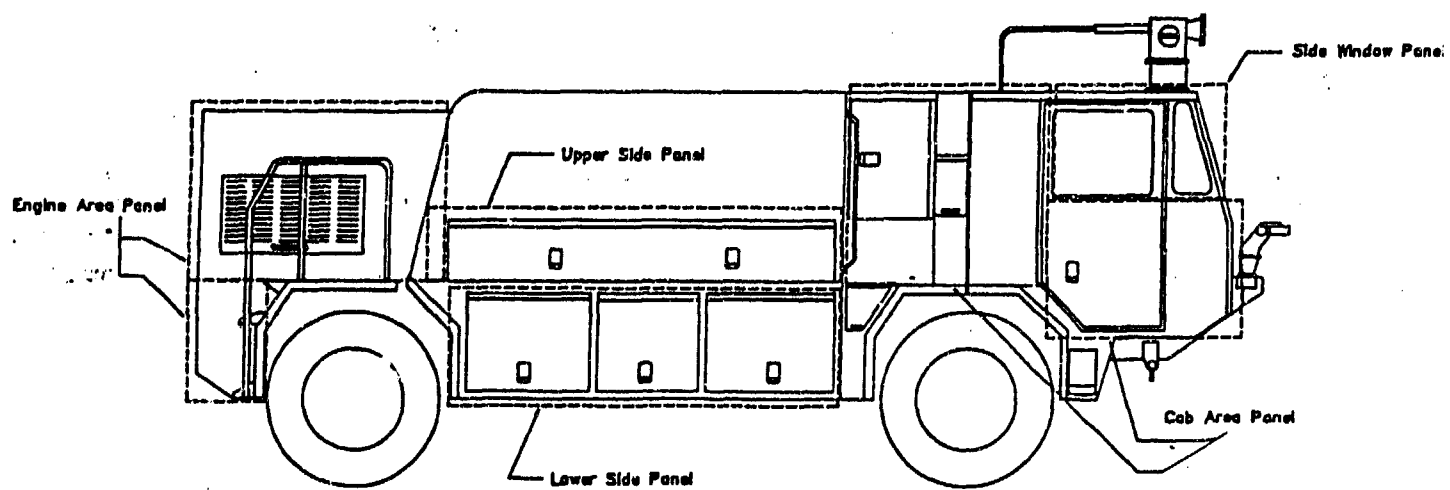


Figure A-4. Target Panels, Side



Figure A-5. P-19 Ready for Hardening Kit Installation

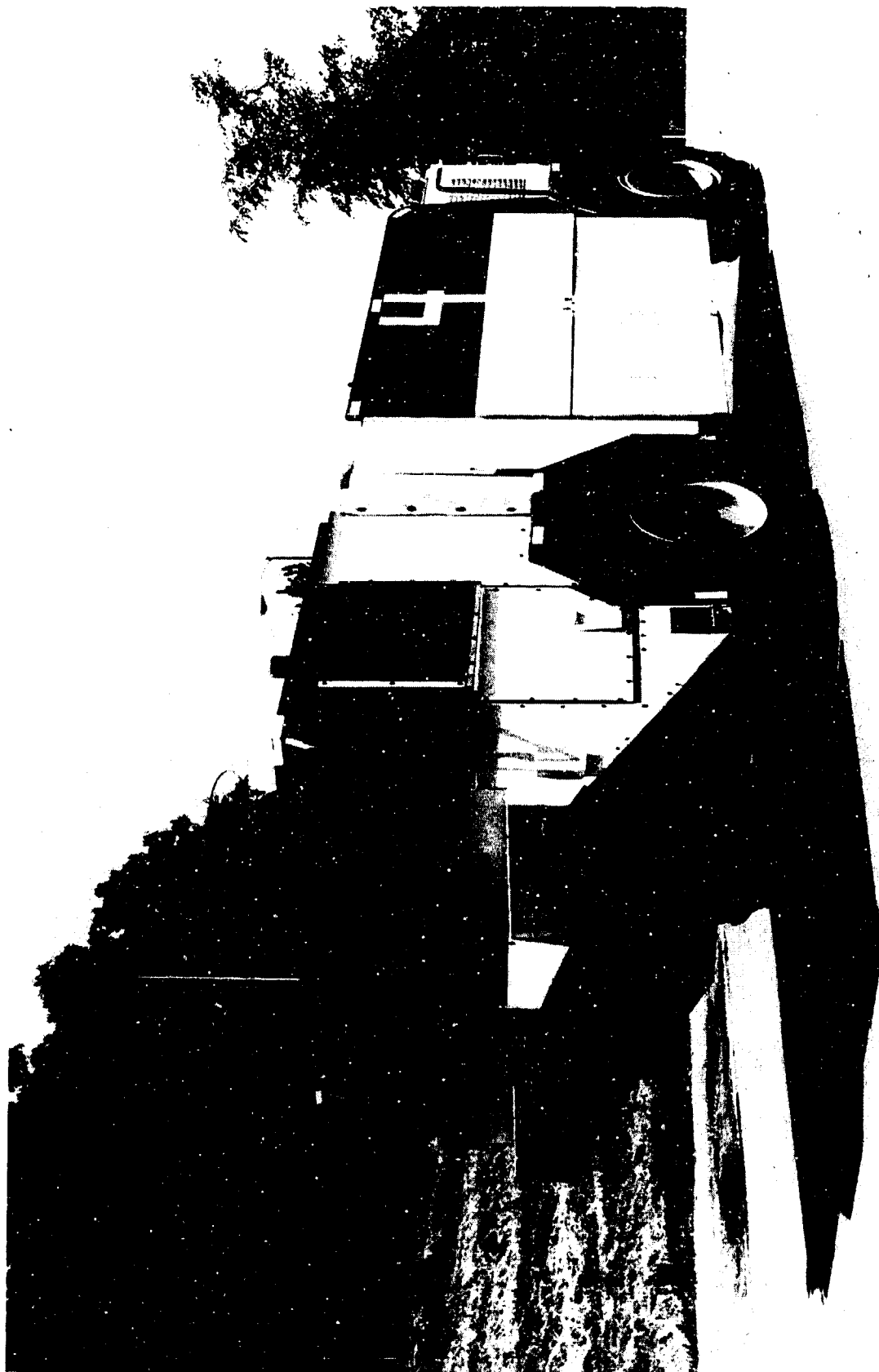


Figure A-6. P-19 with Hardening Kit Installed, Front-Left View

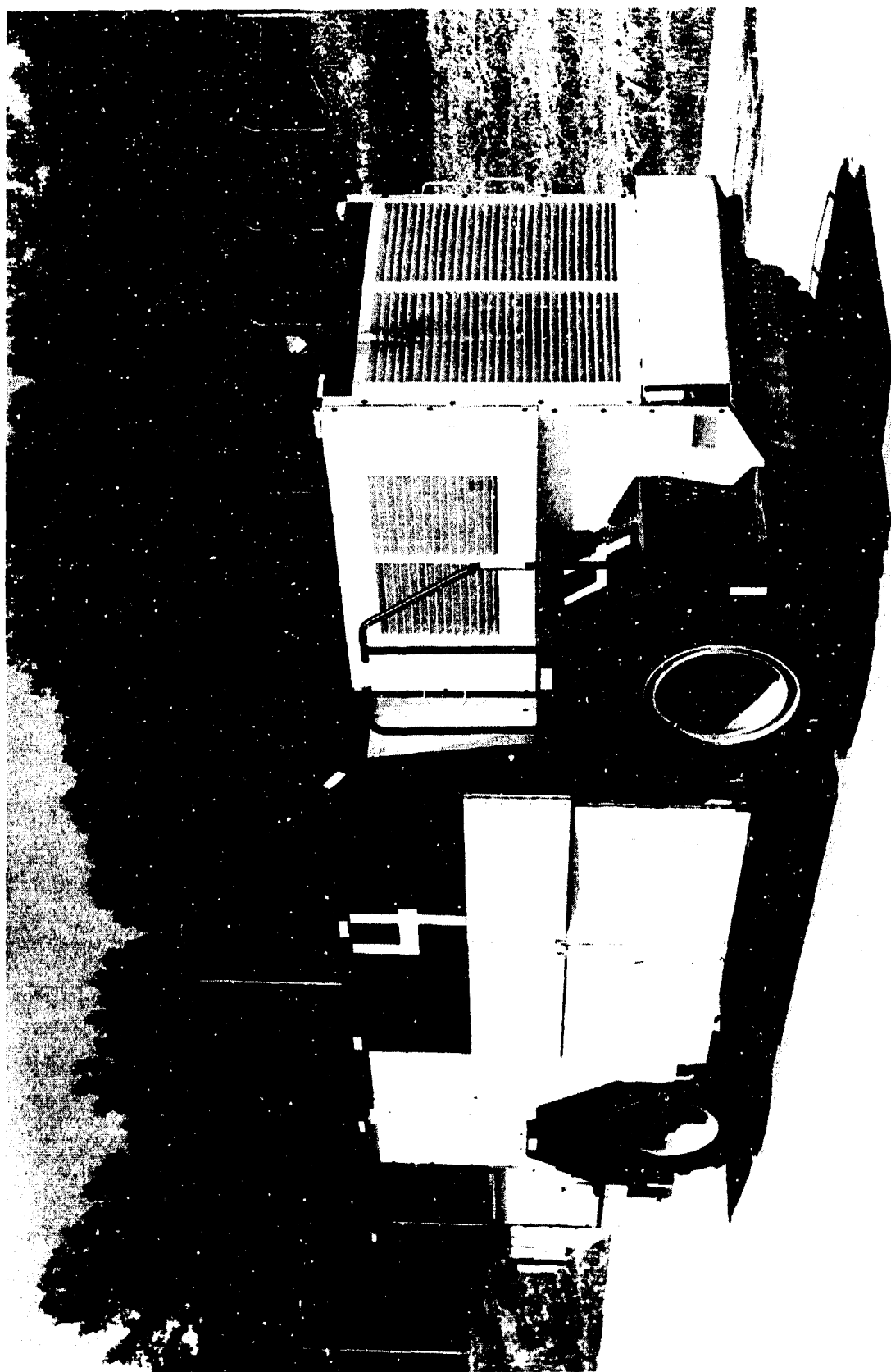


Figure A-7. P-19 with Hardening Kit Installed, Left-Rear View



Figure A-8. P-19 with Hardening Kit Installed, Bottom Rear View

Install the kit per Installation Drawings MIE-T-1530-A and MIE-T-1531-A, Detail Drawings MIE-T-1530-B through MIE-T-1548, and the following procedure.

**NOTE:** Initial each item on the procedure as it is completed.

1. Verify that the vehicle engine is serviced.
  - a. Oil level satisfactory.
  - b. Coolant level satisfactory.
  - c. Visually inspect and correct any engine compartment deficiencies.
  - d. Secure the engine compartment covers.
2. Park the vehicle on a level surface. A hard surface concrete pad, sheltered from the elements, is preferred.
3. Chock the wheels to assure that the vehicle remains stationary.
4. Open Container 10 and remove the box labeled "Tools & Hardware."
5. If no convenient external compressed air source is available, open the lower right side access door to gain access to the compressed air quick-disconnect fitting and shutoff valve located in the compartment.
6. If no convenient external source of compressed air is available, attach the air hose with the appropriate air-operated wrench to the compressed air quick disconnect fitting located in the compartment.
7. If plugs are installed in the armor attachment points, remove the plugs by prying them out with a screwdriver or similar tool. The plugs may be removed just before installing each panel. The belly armor is to be installed first, therefore, start plug removal from underneath the vehicle. Save plugs for future use.
8. If the vehicle compressed air source is to be used, verify that the vehicle is securely chocked, leave the gear selector in the "park" position, and start the engine. Verify that the air hose is connected to the quick disconnect fitting and open the air shutoff valve.

**CAUTION:** When the engine is running, vehicle must be in a well-ventilated area, or the exhaust gas must be ducted to the outside!
9. Remove the belly panel support brackets from Container 1 and install. Torque all bolts to 20 ft-lb.
10. Remove the belly panels from Container 2 and install belly panels. Torque all bolts to 20 ft-lb.
11. Remove all but two of the bolts on the existing front skid plate in order to assure that it remains in place, then install the front skid armor panels which are located in Container 1.
12. Remove the left rear wheel by jacking through the access hole in the rear belly pan armor panel, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.



13. Remove the parts from Container 8, install the left rear wheel armor panels, and torque all bolts to 20 ft-lb.

14. Install one of the foam-filled tires in place of the left rear tire, remove the safety blocking, lower the vehicle, and remove the jack.

15. Remove the right rear wheel by jacking through the access hole in the rear belly pan armor panel, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.

16. Install the right rear wheel armor panels found in Container 9 and torque all bolts to 20 ft-lb.

17. Install one of the foam-filled tires in place of the right rear tire, remove the safety blocking, lower the vehicle, and remove the jack.

18. Remove the right front wheel by jacking, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.

19. Install the right front wheel armor panels found in Container 6 and torque all bolts to 20 ft-lb.

20. Install one of the foam-filled tires in place of the right front tire, remove the safety blocking, lower the vehicle, and remove the jack.

21. Remove the left front wheel by jacking, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.

22. Install the left front wheel armor panels found in Container 7 and torque all bolts to 20 ft-lb.

23. Install one of the foam-filled tires in place of the left front tire, remove the safety blocking, lower the vehicle, and remove the jack.

24. Prior to installing the side armor, remove bolts under the cab steps, remove bolts where side stairwell doors are to be installed, and remove bolts holding the back steps. Hand holds on the truck should be removed when they interfere with armor installation.

25. Remove and install the remaining armor panels that are stored in containers marked 3, 4 and, 5 and torque the bolts to 20 ft-lb.

26. Remove the vehicle windshield wipers and the downspouts.

27. Remove the Lexan™ window panels from their container. Use care not to scratch the surface of these panels.

28. Reverse the bolts holding the rear view mirrors.

29. Using hand wrenches only, install the Lexan™ window panels and the headlight covers. Do not over tighten the bolts and crack the panels. Bolts on the Lexan™ panels should be tightened to 10 ft-lb torque.

30. Install the windshield wiper extensions and reinstall the windshield wipers.

31. If the truck air supply was used for powering the air wrench, close the air shutoff valve in the compartment and disconnect the air line from the quick disconnect fitting.

32. Visually inspect entire armor installation and verify that vehicle is ready for operation.

33. Store all removed hardware and equipment for future use.

34. Sign and date below indicating that procedure is complete.

Procedure completed by: \_\_\_\_\_ Date: \_\_\_\_\_

## **I. KIT REMOVAL PROCEDURE**

Remove the P-19 Hardening Kit per the following procedure and store the kit in the containers detailed in Drawings MIE-T-1549 through MIE-T-1555.

1. Park the vehicle on a level surface. A hard surface concrete pad, sheltered from the elements, is preferred.

2. Chock the wheels to assure that the vehicle remains stationary.

3. If no convenient external compressed air source is available, open the lower right side access door to gain access to the compressed air quick disconnect fitting and shutoff valve located in the compartment.

4. If no convenient external source of compressed air is available, attach the air hose with its impact wrench to the compressed air quick disconnect fitting located in the compartment.

5. If the vehicle compressed air source is to be used, verify that the vehicle is securely chocked, leave the gear selector in the "park" position, and start the engine. Verify that the air hose is connected to the quick disconnect fitting and open the air shutoff valve.

**CAUTION:** When the engine is running, vehicle must be in a well-ventilated area, or the exhaust gas must be ducted to the outside!

6. Remove the windshield wipers and windshield wiper extensions.

7. Exercising care to not scratch the Lexan™, remove the Lexan™ window panels and the headlight covers and store them in Container 10.

8. Reinstall the windshield wipers and the downspouts.

9. Remove the cab, side, and engine panels and store in the original containers.

10. Reinstall and torque the bolts under the cab steps, where the side stairwell doors were installed, and the bolts holding the back steps.

11. Reinstall the truck handholds that were previously removed.

12. Remove the left front wheel by jacking, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.

13. Remove the left front wheel well armor panels and store in Container number 7.

14. Install the original tire in the left front position, remove the safety blocking, lower the vehicle, and remove the jack.

15. Remove the right front wheel by jacking, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.

16. Remove the right front wheel well armor panels and store in Container 6.

17. Install the original tire in the right front position, remove the safety blocking, lower the vehicle, and remove the jack.
18. Remove the right rear wheel by jacking, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.
19. Remove the right rear wheel well armor panels and store in Container number 9.
20. Install the original tire in the right rear position, remove the safety blocking, lower the vehicle, and remove the jack.
21. Remove the left rear wheel by jacking, providing safety blocks under the wheel rim, and removing the wheel per normal procedures.
22. Remove the left rear wheel well armor panels and store in Container number 8.
23. Install the original tire in the left rear position, remove the safety blocking, lower the vehicle, and remove the jack.
24. Remove the front skid panels and store in Container 1.
25. Remove the belly panels and store in Container 2.
26. Remove the belly panel brackets and store in Container 1.
27. Install plugs in all armor attachment points if desired.
28. Store all remaining hardware and tools that were supplied with the kit in the "Tools & Hardware" box and place this box in Container 10.
29. Visually inspect the truck and verify that the vehicle is ready for operation.
30. Sign and date below to indicate that procedure is complete.

Procedure completed by: \_\_\_\_\_ Date: \_\_\_\_\_